Marine Engineering

Volume XXV **SEPTEMBER, 1920** **Number 9**

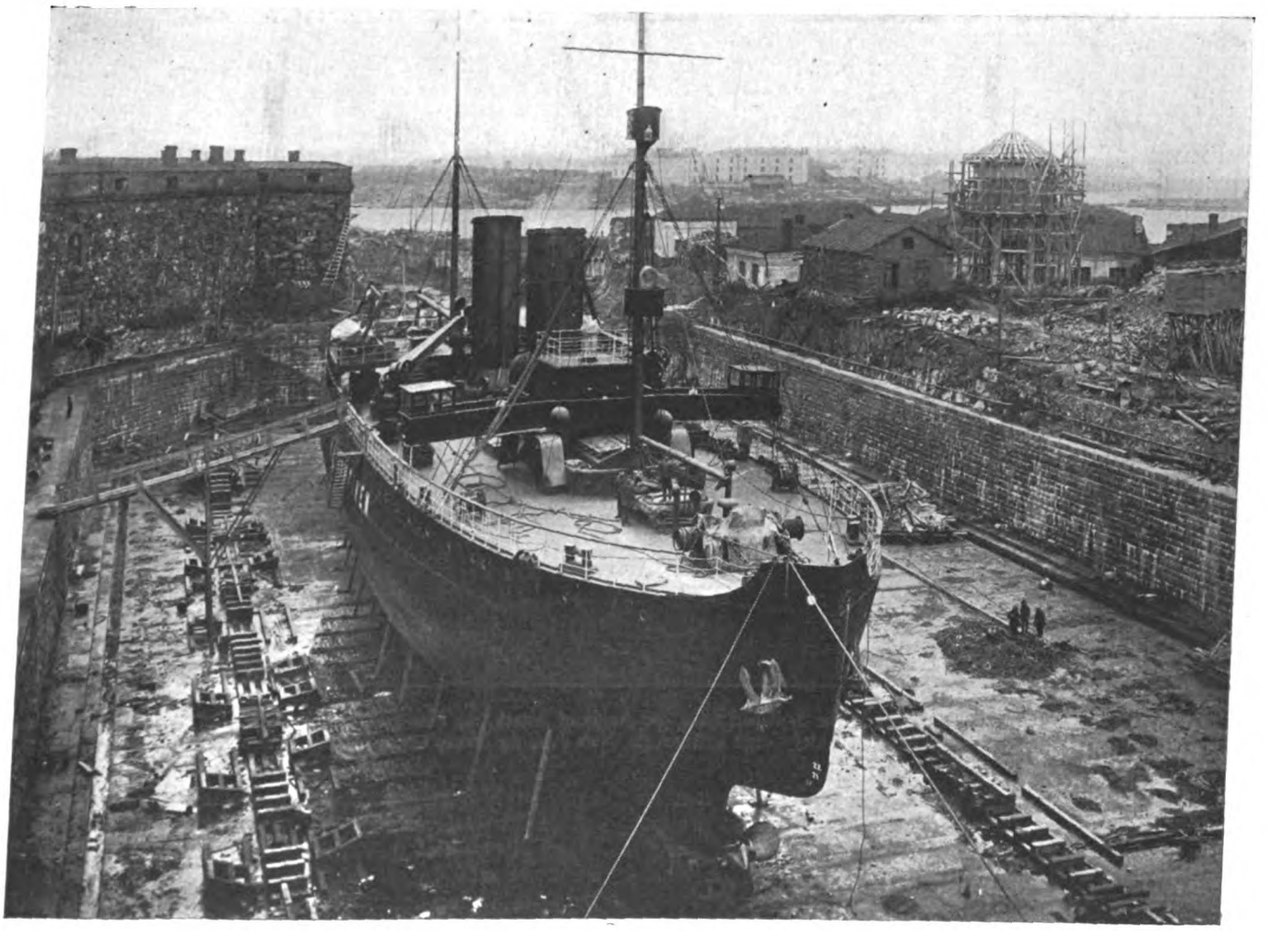

Fig. 1.—Deck View of Ice-Breaker *Vainamoinen.* The Vessel is in Dry Dock at Sveaborg Fortress

Ice-Breakers

Characteristics of Vessels Designed Expressly as Ice-Breakers —American and European Practice—Work in Pack-Ice

BY JOHN FLODIN

THE year 1851 is given as the date of the first record of a vessel built expressly for the purpose of forcing its way through ice. It should be noted that this is the period in the history of navigation and shipbuilding when steam and steel were already the acknowledged masters of the ocean and when the screw propeller was rapidly gaining friends. It was in 1851 that Fincham wrote his famous paper on screw propulsion, in which he deprecated that engineers in England were reluctant to admit the superiority of the screw, in spite of the towing test between the *Alecto* and the *Rattler,* which in 1845 had given such conclusive evidence in support of his views. The advent of the screw propeller may be regarded almost as a prerequisite to the development of the ice-breaker, for paddle-wheel propulsion would, of course, offer very serious obstacles to navigation in ice.

However, little is heard of ice-breakers before the year 1871, when the ice-breaker *Eisbrecher I* was built by Fr. Steinhaus in Hamburg, to keep the Elbe open.

Classification of Ice-Breakers

The *Eisbrecher I* is generally regarded as the first successful vessel built expressly and solely for the purpose of keeping harbors open to winter traffic. Some ice-breaker characteristics have, however, been incorporated in many vessels built primarily for other purposes, both

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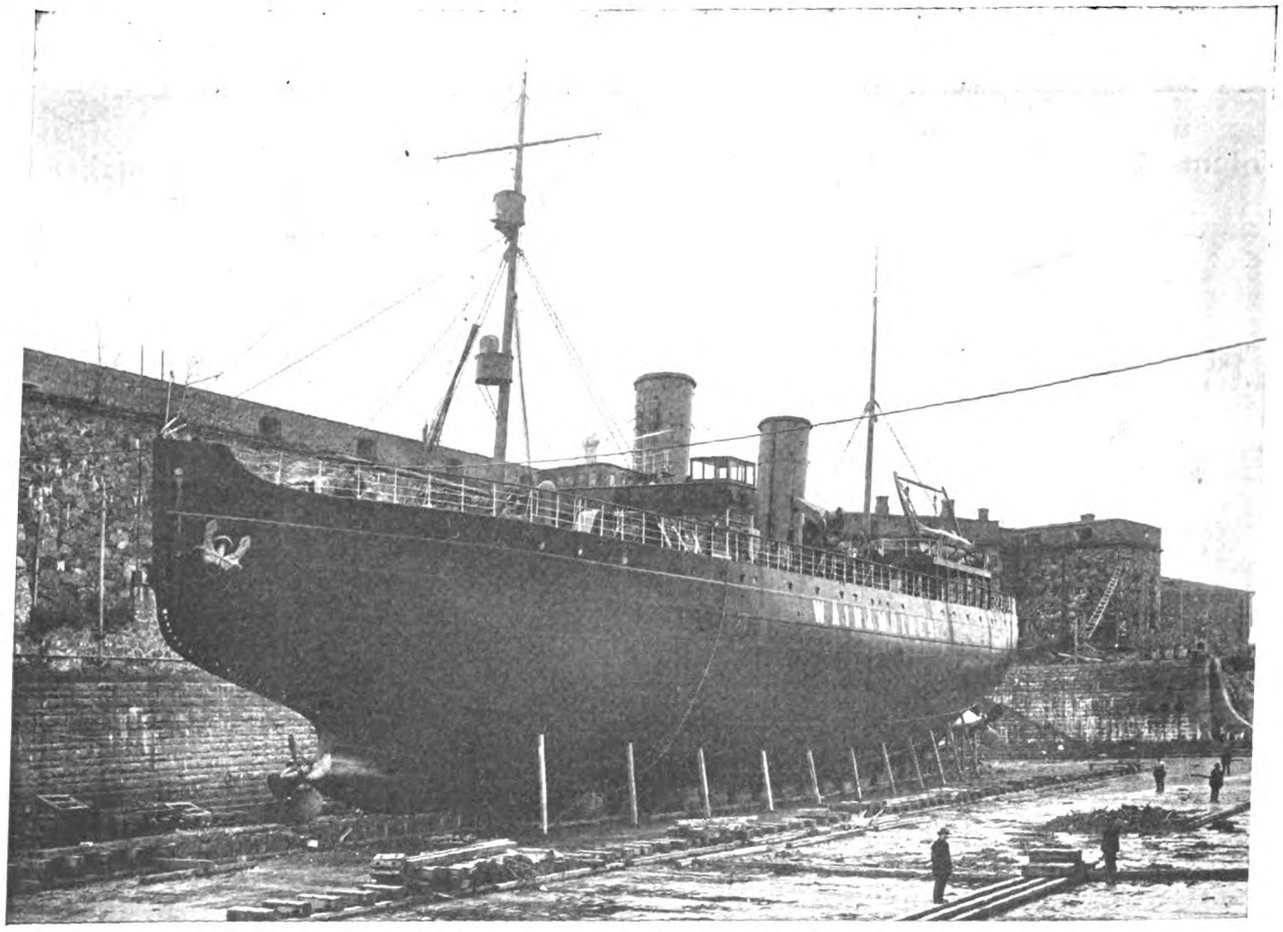

Fig. 2.—Bow View of the *Vainamoinen*. The S-shaped Stem, the Angle of Attack, the Fine Run and Buttock Angles, and the Chubby, High-Speed Bow Propeller Are the Chief Points of Interest. Note Also the Sweep of the Bottom from Keel to Waterline

before and after the time of the *Eisbrecher I*, so that we may say that ice-breakers can be classified in two groups:

(1) Ice-breakers pure and simple.

(2) Commercial vessels incorporating some of the characteristics and qualities of ice-breakers.

In vessels of the first group, the entire ship is given over to the machinery, equipment and crew necessary or desirable for ice-breaking purposes, while in the latter class the extent to which deadweight capacity, cargo or passenger space and speed are sacrificed in order to enable the vessel to force its way through ice becomes an economic question the solution of which depends largely upon the ice conditions in the ports to which it is intended to run the vessel.

Although the second group offers many points of interest, as much because the vessels belonging to it are steadily growing in both number and size as because of the often delicate task of balancing ice-breaking power with economical operation, we shall here confine our attention to vessels of the first group. This group is, in turn, commonly subdivided into:

(*a*) Vessels of the European type.

(*b*) Vessels of the American type.

The European Type

To the designer of *Eisbrecher I* is due the credit for having ushered into the world not only the first successful ice-breaker, but also the fore-runner of the so-called European type of ice-breaker. Curiously enough, this vessel incorporated all the chief characteristics that until relatively lately were regarded as necessary and sufficient for successful ice-breakers.

The principle of ice-breaking employed was to crush the ice downward, rather than to try to plow it to the sides, the stem having been given such a slope that the force of the vessel's movement against the ice gives rise to a vertical downward component of a greater magnitude than the horizontal forward component. To force heavy ice, or pack-ice, it is, however, often necessary to back away and to run against the ice at full speed, thus driving the bow of the vessel some distance on top of the ice.

The forward part of the vessel is somewhat raised, and its weight, augmented by water ballast, serves to crush the ice. For work of this nature, a vessel of extremely heavy construction and fitted with extraordinarily powerful engines is, of course, necessary.

Proportions and Lines

Another conspicuous peculiarity of the ice-breaker is the breadth to length ratio, which usually is about 1 to 4. The reason for this is to be found in another peculiarity, namely, the great stern draft, given the vessel in order to keep the propeller blades as much as possible out of danger from solid ice. It is principally for the purpose of securing good stability in spite of the great draft that the breadth is made so large. Since vessels of this type are not intended to navigate in open sea-ways, there is no great disadvantage in having a somewhat unusually large metacentric height, but great breadth also offers the advantage of better maneuvering qualities in narrow waters.

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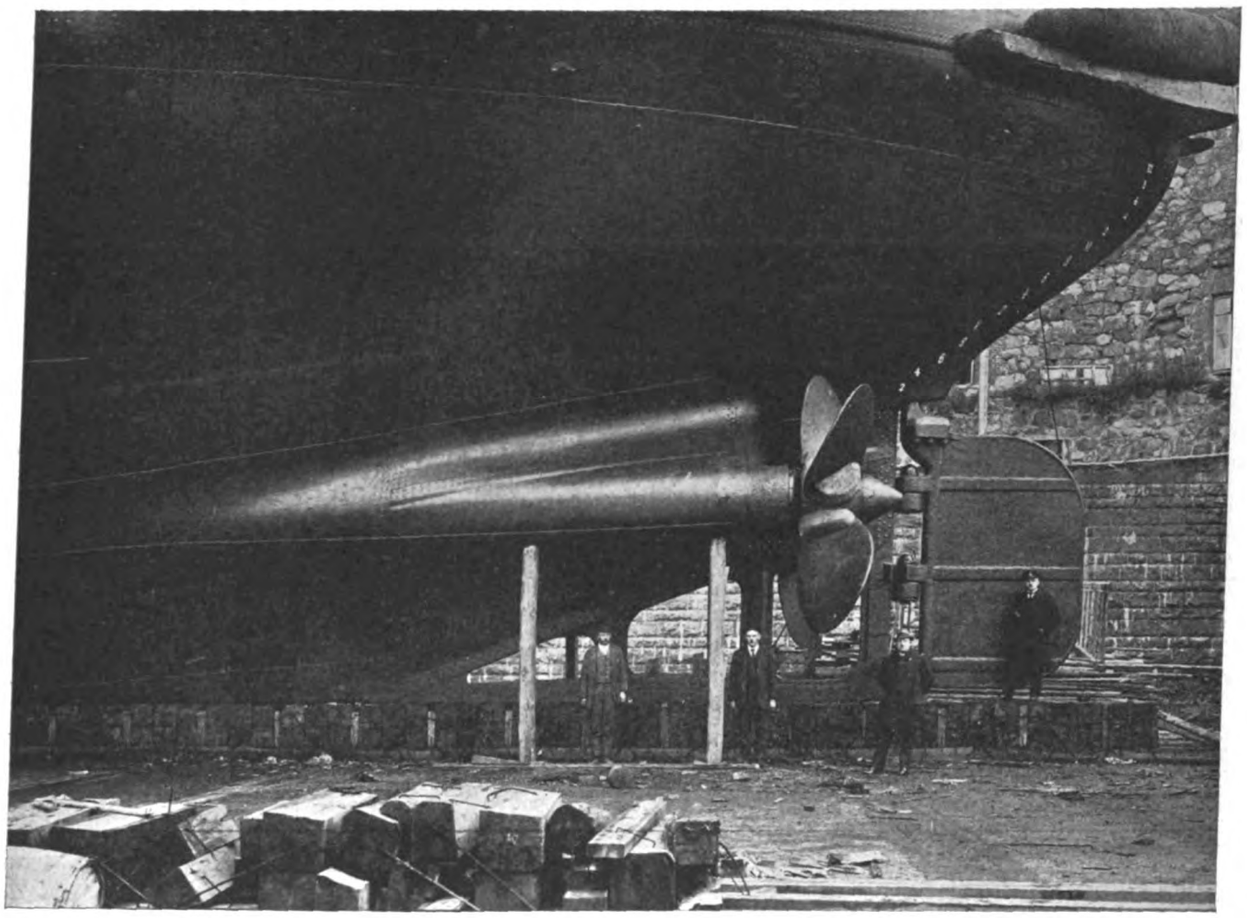

Fig. 3.—Stern of the *Vainamoinen*. Note the Heavy Propeller Blades, the Sturdy Rudder Construction and the Full Load Waterline as Compared to the Relatively Fine Run

and of making the wake, or the cut in the ice, broader.

As to the lines, the most notable difference between the ice-breaker and an ordinary mercantile steamer is seen in the great deadrise and bilge radius of the former, which gives an almost yacht-like underwater body. This body form affords the broken-up ice a better opportunity to get away, as it may disappear under the vessel, where it becomes further broken up as it moves towards the stern. Aft the waterlines below the load waterline are made quite fine, so that the flow of water to the wheel and the rudder is considerably more parallel than is usual in commercial vessels of anything like the same breadth to length ratio, giving again a yacht-like effect. The stern is, however, made full at the waterline, a low counter of considerable size being provided. The reason for this is the need to give the after body above the load waterline as much buoyancy as possible, so as to keep the stern from sinking unduly when the bow is run on the ice. Furthermore, a full load waterline aft tends to cause a large stern wave, which helps in breaking up loose blocks of ice.

Some of the older ice-breakers were given a flare along their whole length, but the modern practice is to give a quite considerable tumble-home above the load waterline, so that the entire side of the ship forms a continuous convex surface, except for the hollowing at the run. The bellying of the ship's side at the waterline tends to prevent jamming in the ice and offers the further advantage that the vessel, in case it should be frozen in, can be freed by listing. For this purpose the latest ice-breakers are, in fact, provided with wing ballast tanks so connected by means of pipe lines that the water may be pumped from one side to the other.

The *Eisbrecher I* had a rather full bow with a sloping stem, a construction that was so successful that it was first copied and later modified in an effort to produce something even more effective. The result was a spoon bow, which, though very satisfactory in breaking clear ice, soon showed itself impossible in ice covered with snow. Snow, and especially wet snow, has the unpleasant characteristic of walling up before and around the bows of the ice-breaker, forming a cushion ever increasing in size and hardness, making the task of driving the bows of the vessel on the ice ever more difficult and perhaps finally impossible.

On the basis of the experience just gained, the bow construction of the *Eisbrecher I* was returned to, and subsequently the lines forward were made materially finer, giving a rather sharp bow. This soon showed itself in many respects so much superior to the fuller bows that it immediately won favor. The sharper bow construction was first proposed by the Finnish engineer R. Runeberg, who, as a member of the committee of experts employed by the Finnish government to draw up specifications for the *Murtaja*, objected to the spoon bow, pointing out that all the angles of attack should be made quite fine, that is, the angle of the stem with the horizontal, the entrance angles of the waterlines, and the angles of the buttocks with the horizontal. The *Murtaja* was, however, built with a spoon-shaped bow, but it was the last ice-breaker so constructed (1889).

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Particulars of Typical Ice-Breakers

NAME AND OWNERSHIP / EUROPEAN TYPE	LENGTH OVERALL FEET	BEAM AT D'K FEET	BEAM MLD. FEET	DRAFT AFT, COAL ON BOARD FEET	DISPL. TONS	INDICATED HORSEPOWER FOR'D	INDICATED HORSEPOWER AFT	INDICATED HORSEPOWER TOTAL	SPEED IN CLEAR WATER, KNOTS	STEM ANGLE OF ATTACK, DEGREES	TYPE OF BOW	YEAR BUILT	APPROX. COST, DOLLARS	WHERE BUILT	REMARKS
Berlin (Stettin)	141.2	35.4		16.0	630		900				Spoon	1889	79,400	Stettin, A. G. Vulcan	
Murtaja (Finland)	156.1		35.8	17.0	824		1,260			33	Spoon	1890	138,400	Stockholm, Bergsunds Mek. Verkstad	
Eisbrecher III (Hamburg)	146.3	36.05		15.1	860		1,200			40	Full	1892	122,000	Hamburg	
Isbjorn (Christiania)	123.1	32.5		17.6[1]	630		1,200			45	Full	1893	74,200	Christiania	
Bore (Malmo)	133.1		29.0	13.0	400		600			40		1894	41,600	Malmo	
Isbrytaren II (Gothenburg)	140.2		34.0	18.8[1]	720		1,300				Full	1895	88,000	Gothenburg	
Stadt Reval (Reval)	148.0		38.8	13.5	865		1,600			30		1895	100,800	Stettin	
Sleipner (Copenhagen)	170.1		39.0	17.75	1,470		2,600		13.5	30	Sharp	1896	168,000	Copenhagen, Burmeister and Wain	
Isbrytaren (Stockholm)	141.2		31.0	16.5	616		1,000		12	40	Full	1897	84,000	Malmo	
Nadeshny (Vladivostock)	180.4		42.5	17.75	1,525		3,000			30	Sharp	1897		Copenhagen, Burmeister and Wain	
Aranee (Abo, Finland)	143.2		34.4	17.8	600		1,500		13.6		Sharp	1899	133,200	Kiel, Horaldts Werke.	
AMERICAN TYPE.															
St. Ignace (Ferries between Mackinaw & St. Ignace, Mich., R.R.	302.2	52.0		17.0	3,640	1,800	2,200	4,000	16	25		{1887 1893	340,000	Detroit	{Ferries not ice-breakers pure and simple
Sampo (Finland)	202.2	43.0	42.0	18.25	1,850	{1,200 (1,400)[2]	1,400 (1,600)[2]	2,600 (3,000)[2]	13.5	22	Sharp	1893	270,200		
Jermak (Russia)	302.6	71.0		25.0	8,000	2,500[3]	7,500	10,000[3]	15.5	20	Sharp	1899	798,000	Newcastle-on-Tyne, Armstrong, Whitworth & Co.	
Tarmo (Finland)	220.0	47.1	46.9	18.25	2,300	{1,300 (1,450)[2]	1,700 (2,400)[2]	3,000 (3,850)[2]		22	Sharp	1907	326,400		
Peter der Grosse (Riga)	182.3	50.8	48.5	21.3	1,900	800 (1,200)[2]	1,800 (2,800)[2]	2,600 (4,000)[2]	14.5		Sharp	1912	352,000	Gothenburg	{700 tons water ballast Can. working and Ball. pumps 2,500 tons per hour
Vainamoinen[4]	300.0	60		21.0		2,400	3,600	6,000	15		Sharp	1914		Stettin, Vulcan One of several sisters	

[1] Draft with ballast.
[2] Figures in parentheses indicate horsepower with forced engines.
[3] Forward engine and propeller removed from *Jermak*, and bow rebuilt, in 1909.
[4] Ex-*Volynets*, ex-*Tzar Michael Feodorowitch*.

The first vessel that incorporated Mr. Runeberg's ideas on bow construction was the Swedish gunboat *Svensksund*, designed by Mr. G. W. Svenson in 1891. Successful though this construction was, the sharp bow caused much unfavorable comment. Many designers regarded it as too weak, and subsequent vessels were consequently given a bow that either approached the full form of the *Eisbrecher I* or the fine lines of the *Svensksund*, in accordance with the designer's idea of strength, durability and efficiency. In the appended table are given the stem angles of attack and type of bow for a number of typical ice-breakers.

The American Type

The so-called American type of ice-breaker is differentiated from the European type by the one peculiarity that vessels of the American type have a propeller forward. As a consequence of this, the drag is lessened or entirely obviated.

The efficiency of the forward propeller in breaking through ice was discovered on the Great Lakes, where it had been found that a loaded vessel could back its way through ice when it could not get through otherwise. It seemed evident that the screw, in backing through the ice, served the complex purpose of propelling the steamer, of disturbing the water under the ice that was to be broken and of helping to move the broken-up ice towards the rear. Deprived of the solid support of still water, the ice was relatively easily broken through.

Acting on this theory, Mr. Frank E. Kirby designed the railroad ferries *St. Ignace* and *St. Marie*. Although these vessels cannot be classified as ice-breakers pure and simple, their particulars are given in the appended table in order to afford a comparison with the later vessels that were inspired by the ferries. For these vessels showed themselves to be such excellent ice-breakers that the idea was promptly copied by European designers. In fact, the Finnish government, which was then contemplating building another ice-breaker, sent a commission to America to study the new ideas incorporated in the *St. Ignace*. As a result of the work of this commission, the bow propeller was called for in the specifications for the *Sampo*, which was built in 1893 for the Finnish government.

This, so far as I know, was the first pure and simple ice-breaker of the American type ever built in Europe. But it was soon to be followed by others. The Russian government, perhaps in a spirit of giantism, decided that it should not be outdone by its small neighbor and ordered the huge ice-breaker *Jermak* (or *Ermak**), which was designed by Admiral Makaroff.

Large as the *Jermak* is, she has not been an unqualified success, either from an economic viewpoint or as an ice-breaker. She was built primarily to operate in the Gulf of Finland, and her first duty was to keep the port of Petrograd open. One might well think that, if this task is at all within the realm of human endeavor, the *Jermak* should be able to do it with her 8,000 tons displacement and 10,000 indicated horsepower. But the services she was actually able to perform—reports of the Russian

* For illustrations of the *Ermak*, see article on Shipbuilding in Encyclopedia Britannica.

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naval engineers to the contrary—were not materially greater than those performed under practically identical conditions by the *Sampo*, a vessel of but 1,850 tons displacement and a maximum of 3,000 indicated horsepower.

Captain L. Melan, a veteran in ice-breaker work, who at that time was commander of the *Sampo*, has expressed to me the belief that the reasons why the *Jermak* did not make a better showing were that she was not properly handled, that she was not properly designed, and that she was altogether too large. The first indictment seems to some extent supported by other evidence. The second and third statements may be regarded as coinciding, for is not the choice of dimensions the first step in every design?

It seems very probable that a vessel of the size of the *Jermak* would be extremely difficult to maneuver in heavy ice, and all the more so when the waters are as narrow as many of the passages in the Gulf of Finland are. The *Jermak* has, however, furnished another very valuable lesson in ice-breaker design.

In 1909 it was decided to send her to the Arctic, but it was feared that the work in the heavy ice of the Far North would endanger the bow propeller. She was consequently sent back to England to be dry docked, and there the entire bow was reconstructed and the forward engine taken out. It is said that the official report, presumably made by the gentlemen who ordered the work done, states that the removal of the forward engine made no appreciable difference in the ship's ability to break ice. This, however, is false, for where it now became necessary for the *Jermak* to stop, back and get a good, long start so that she could break her way through the ice by running her great weight on it, the *Sampo*—a vessel, remember, of less than one-fourth the displacement and about one-third the horsepower of the *Jermak*—could often go through without a single stop. It seems that this experience would conclusively show the value of the forward propeller, even if there were no other evidence available.

The mere fact that the latest ice-breaker built for the Russian government, the present *Väinämöinen*, was ordered with a forward engine appears to be a confession that the removal of the bow propeller from the *Jermak*

Fig. 4.—The *Tarmo* in Relatively Light Pack-Ice

was a mistake. But the efficiency of the forward propeller need not be based on the experience of the *Jermak* alone, for it is a matter of common observation. It has often been noted that when an ice-breaker forcing clear ice is running full speed ahead, with the bow propeller working, the water forward of the vessel is sufficiently disturbed to cause ice up to from four to six inches in thickness to break before the stem actually reaches the edge of the solid ice. The ice is, so to speak, torn to pieces by the suction of the bow propeller.

In pack-ice the bow propeller is, however, of even greater importance. This will perhaps be better understood if the formation of pack-ice is first considered.

Under ordinary wind and temperature conditions the ice will freeze to a certain ragged line, beyond which any new ice that may be formed breaks up before it can attain the thickness of permanence. If the temperature remains low and the winds are moderate, the ice may freeze to a thickness of several feet and may be covered with a heavy blanket of snow. If now a storm arises in a direction towards the edge of the ice from the open water, the wave formation will continue under the ice. Not only is

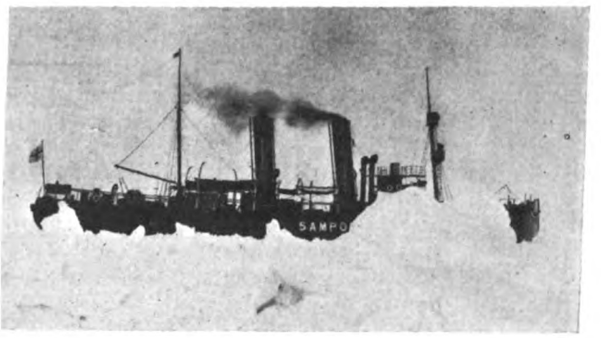

Fig. 5.—The *Sampo* at Work in Pack-Ice

the support of the ice thus made discontinuous, but a heaving movement is started causing ice blocks to break loose. These blocks, varying in size between very large limits, are tossed by the waves and driven by the wind until they form a field consisting of many thicknesses of the original ice, some blocks being piled on top of each other, while other blocks, sometimes quite large, are standing on edge or held in an inclined position.

WORK IN PACK-ICE

This mass may or may not freeze together into a solid field. In either case, the specific gravity of this mixture of snow and ice is often so low that but one-tenth of the mean thickness of the ice is below the surface of the water, while a ragged nine-tenths form a field that is all but unpassable for the human animal, full as it is of treacherous holes and crevices that often are covered with snow-slush that make them appear to be solid ice.

It is in this sort of ice that the skill of the commander of an ice-breaker is tested most severely. He can never tell how hard the ice blocks are frozen together, nor how soon the whole mass may begin to move. If he is foolhardy and drives his vessel into loose pack-ice, or into pack-ice that may become loose because of the working of the vessel, the lateral pressure that the ice exerts on the sides of the ship may become so great as to stop the ship through friction. And once a vessel is so stopped, it is impossible to move her with her own power, for the friction of the ice will, of course, be greater when the vessel is at rest than when it is moving. There is still hope of moving her, however, without calling in aid from the outside. Ice-anchors may be led out, so that the pull of windlass and winches may be added to the pull of the main engines, and in some cases blasting may be resorted to with good results.

It is under such ice conditions as these that the bow propeller is most effective. Through its continual churning it serves to draw blocks of ice and snow-slush towards the stern of the vessel, in which work the aft propeller or propellers naturally assist. It is, in fact, a principle of ice-breaker design that the length of the vessel must be so balanced with the power plant that the throw of the forward propeller and the suction of the aft propeller must meet somewhere near the middle of the vessel with

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sufficient force to carry the ice towards the stern even when the vessel is standing still. Much ice that otherwise would only be plowed to the sides, where it would serve to increase the friction, is by this means washed under the vessel and then aft.

This kind of work is, of course, extremely hard on the propellers. It is by no means an exception that the blades strike large blocks of ice; nor is it an exception that, when the vessel is forced into pack-ice, the forward propeller is driven into the ice so hard that it suddenly stops. This sort of service naturally necessitates extremely heavy propeller construction and engines, especially the forward engine, so designed that they are as nearly shock-proof as possible. It is evident from this that oil engines, at least in their present state of development, are not suitable for ice-breaker work. Producer gas engines have been proposed for the stern screws, while the bow screw would be driven by a reciprocating steam engine, but it does not seem likely that this sort of arrangement would prove satisfactory.

Some Ice-Breaker Data

The table given on page 710 is intended to show in a fairly representative way the changes that time has wrought in ice-breaker construction. It will be noted that, with the exception of the *Jermak*, there is but one vessel of more than 2,300 tons displacement, namely, the *Väinämöinen*, whose displacement is somewhat less than 5,000 tons. All the other ice-breakers are materially smaller, the two American ferries given on top of the group of "American Type" ice-breakers not being included in this comparison, since they are not purely ice-breakers.

The column headed "Stem Angle of Attack" gives the angle of the stem at or some little distance below the load waterline. In cases where the stem is S-shaped (see Fig. 2), the angle of the straight underwater portion of the stem with the horizontal is regarded as the angle of attack. The small angle of attack of the *Jermak* (20 degrees) has been offered as an explanation why that vessel has not proven more efficient. It is contended that when the angle is too small the bow may be driven on the ice as far as the forward propeller without raising the vessel sufficiently to give the necessary crushing force. It seems, however, that the great weight of the *Jermak* should offset this error, if, indeed, it is an error. In general, angles of attack of from 25 degrees to 35 degrees seem to have given the best results.

The Vainamoinen

As a good illustration of the latest ideas in ice-breaker construction, the *Väinämöinen* may be studied. She was built by Vulcan in Stettin, one of several sisters ordered by the Russian government, and was delivered just prior to the outbreak of the war. She has a length of 300 feet, a beam of 60 feet and draws 21 feet. The power plant consists of three reciprocating engines, all alike. Of these, the two after engines, operating twin screws, develop 1,800 indicated horsepower each, while the forward engine, operating the bow propeller at a higher rate of revolutions, indicates 2,400 horsepower, or a total of 6,000 indicated horsepower. Steam is furnished by six single-ended Scotch boilers. Coal is used as fuel, the bunker capacity being 700 tons, but provision is made for the use of wood in case coal should not be obtainable.

Even more interesting than the main power plant is, however, the auxiliary equipment, numbering some thirty-odd machines. It is perhaps not surprising to note that some of the pumps on board this ship—a ship that is now flying the Finnish flag, that was ordered by the Russian government and that was built at a German shipyard—bear the name-plates of a well-known American manufacturer, and that the engineer in charge has declared these pumps entirely satisfactory. The ballast pumps get an extraordinarily hard usage, since both the transverse and the longitudinal trim may be changed at any time and at frequent intervals. In order to facilitate this changing of trim, the ballast piping is so arranged that the water may be pumped overboard from any number of the tanks, or it may be pumped from one set of tanks into the opposite set of tanks. For example, if the ship is frozen in and it is desired to free her by listing, the ballast tanks in one wing are filled and then the water is pumped from these tanks into the tanks in the other wing. In the neighborhood of 300 tons of water are thus moved across the ship in from 12 to 15 minutes. The entire engine and boiler room equipment seems to have fulfilled every expectation. To quote the first assistant engineer, who very kindly showed me around in the machinery spaces: "The Russians may not be great shipbuilders themselves, but they certainly know how to demand and how to get good work from others." Which, perhaps, is a good substitute for doing good work yourself.

The deck machinery is electrically operated, which gives the advantage of obviating the use of steam pipes that may be found to be frozen when their service is suddenly most urgently needed. The ship is further furnished with an electrically driven, portable salvage pump, which may be carried in a boat or on a sled over the ice to a damaged vessel which the ice-breaker cannot othewise reach, either because of ice conditions or because of too shallow water.

The illustration herewith given of the *Väinämöinen* shows quite clearly the construction of the hull at the ends and the character of the propellers used. It will be noted that the stern is fairly fine, and that, while the load waterline aft is rather full, this ship has not the heavy counter mentioned as a characteristic of the older vessels. The bottom sweeps up to the waterline in a single long curve, giving a sort of modified V-shaped underwater body, so that one can scarcely speak of a bilge radius.

The impression of strength and sturdiness that the pictures give is an indication of the heavy, solid construction that is the first characteristic of all ice-breakers.

A 10,000-Ton Floating Dry Dock for Schiedam

THE New Waterway Shipbuilding Company has recently installed at its Schiedam shipyard, near Rotterdam, a floating dry dock having a lifting capacity of 10,000 tons, built by Swan, Hunter and Wigham Richardson, Ltd., at Southwick, near Sunderland, England. The dock was ordered by Messrs. Furness, Withy & Company, which has the chief interest in the New Waterway Shipbuilding Company. It was built during the war and was at once commandeered by the British Admiralty and towed to the Invergordon naval base in the Cromarty Firth.

The dock is 500 feet long overall, 104 feet wide outside and 75 feet wide inside the walls. The pumps, obtained from Gwynnes, Ltd., of London, are driven electrically, the current being taken from a power station on shore. The dock is of the bolted sectional type, composed of three sections, each of which is in effect a complete box dock, and they are bolted together. When self-docking is required for painting or repairs, the three sections are disconnected and then any two of them can lift the third section out of the water.

This new dock was quite invaluable at Invergordon, being able to accommodate light cruisers as well as smaller ships. As it was comparatively near Scapa Flow, a great

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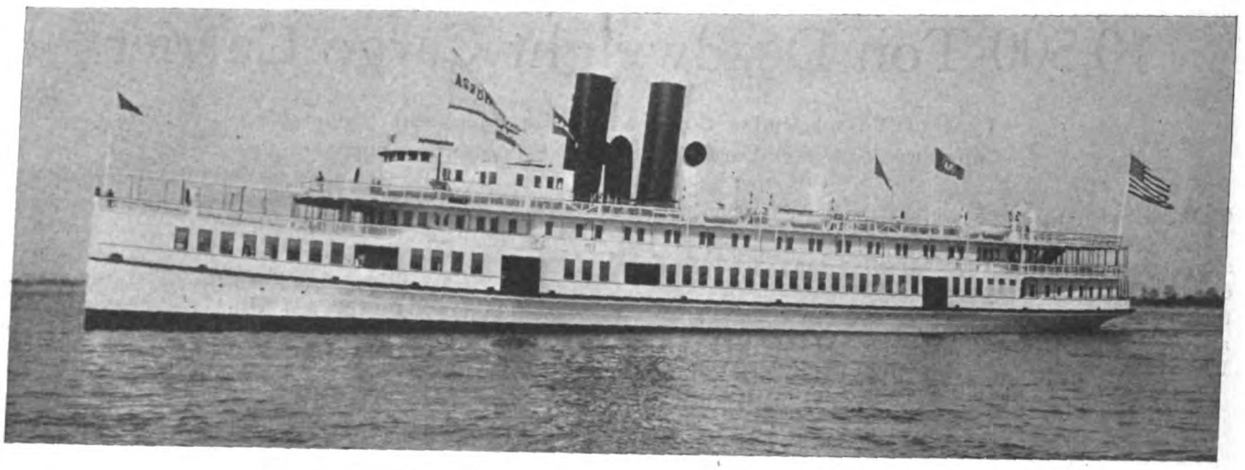

Fig. 1.—The *Asbury Park* as She Appeared in Service in New York Harbor

deal of time was saved by not having to send many ships of the Grand Fleet to Rosyth or more southern ports.

When the Admiralty at last released the dock it was taken to Schiedam by the International Tug Company, of Rotterdam. Three powerful ocean tugs, the *Humber, Schelde* and *Seine* were used for the purpose. The towage was hampered by bad weather and head winds, but in spite of such unfavorable circumstances it was accomplished without any damage whatever being done to the dock. Within three days of arrival at Schiedam, the dock successfully lifted a ship and has continued to be busily employed.

Steamer Asbury Park in Service on the Pacific Coast

BY H. L. DES ANGES

FOR nearly fifteen years one of the most popular passenger steamers in service in New York harbor was the *Asbury Park*, operated by the Central Railroad of New Jersey on the Sandy Hook route from New York to Atlantic Highlands, N. J. She was a steel twin-screw 20-knot flyer built by William Cramp & Sons Ship and Engine Building Company in Philadelphia in 1903. Three years ago C. H. Hatch, of Hatch Bros., San Francisco, which operates the Monticello Steamship Line between San Francisco and the Napa Valley, came to New York to canvass the field for vessels suitable for operation on this line. After a careful survey, Mr. Hatch bought the *Asbury Park* and had her prepared for the trip to San Francisco, which was made via the Panama Canal under her own steam.

Originally the *Asbury Park* was equipped with four Scotch boilers, two of which were double ended and two single ended, designed for coal burning. Subsequently these boilers were replaced with nine watertube boilers with which the vessel made the trip to the west coast. Since her arrival in San Francisco the watertube boilers have been replaced by four shell boilers of the gunboat type. These boilers, in accordance with the prevailing practice on the west coast, have been fitted for burning fuel oil, thereby greatly reducing the number of the crew.

The *Asbury Park* has a length on the waterline of 297 feet 3 inches, a molded beam of 50 feet, and a depth of 17 feet. Propulsion is by two sets of four cylinder, triple expansion, reciprocating engines with cylinders 23 inches, 37½ inches, 43 inches and 43 inches diameter by 30 inches stroke, which at 190 revolutions per minute develop approximately 6,000 indicated horsepower. Designed for a speed of 20 knots, the vessel developed on her trials at the time she was built a speed of 20.5 knots.

The owners state that the venture in bringing the vessel from the Atlantic to the Pacific has proved thoroughly satisfactory and that the popularity which the *Asbury Park* has gained has fully justified the move. As can be seen from the illustrations, the appearance of the vessel has been considerably altered.

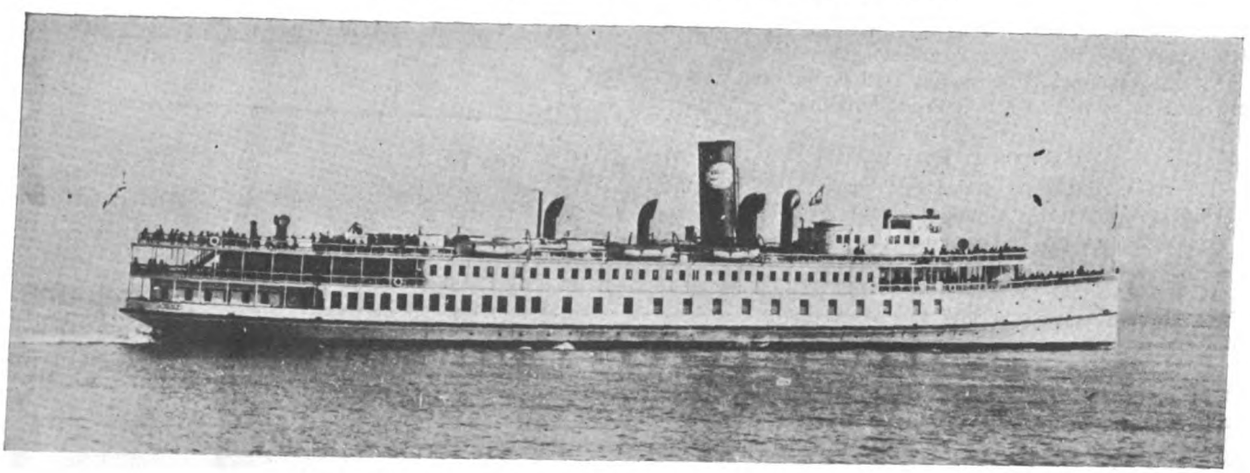

Fig. 2.—The *Asbury Park* as Altered for Service on the Pacific Coast

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10,500-Ton Deadweight Cargo Carrier

Type of Vessel Under Construction for Shawmut Steamship Company at Chester Yard of Merchant Shipbuilding Corporation

THE Chester, Pa., yard of the Merchant Shipbuilding Corporation is building two 10,500-ton deadweight steel cargo vessels for the Shawmut Steamship Company, of New York. These vessels will be built and classed to the rules of Lloyd's Register of Shipping, class 100 A-1, and in compliance with the rules and regulations of the United States Steamboat Inspection Service.

Characteristics

The characteristics of each vessel will be as follows:

Principal Dimensions

Length overall	457 feet	0 inches
Length between perpendiculars	440 feet	0 inches
Beam, molded	57 feet	0 inches
Depth at side to shelter deck	39 feet	0 inches
Depth at side to upper deck	31 feet	0 inches
Depth at side to lower deck	22 feet	0 inches
Draft, designed load	28 feet	9 inches
Displacement at designed load draft	15,000 tons	
Speed on designed load draft	13 knots	

Capacities

Deadweight, designed load draft	10,500 tons	
Cargo capacity, bales	470,000	cubic feet
Fuel oil capacity at 38 cubic feet per ton	2,400 tons	
Drinking water tanks	29 tons	
Reserve feed water	150 tons	

General Description

The vessels are to be of the single screw, shelter deck type with machinery located amidships. A double bottom extends throughout the vessel between the forward and after peak bulkheads, which will be used for the stowage of fuel oil, with the exception of that portion in way of the engine space where the reserve feed water will be carried. There will be three deck erections, viz., a steel bridge house with accommodations on the shelter deck for the deck officers and on the boat deck for the captain with a wooden wheel house and chart room over, a steel midship house with accommodations for the engineers and petty officers and a steel house aft for the steering gear, entrance to quarters below, toilets, etc. The firemen and seamen will be housed aft on the upper deck.

Five cargo holds are provided and 'tween deck cargo spaces on the second and upper decks. Two steel pole masts with wooden topmasts and two king posts will be fitted carrying the cargo handling gear, lights, signals and radio antennae. Ten 5-ton steel booms and one 30-ton steel boom will be provided for handling the cargo.

Machinery Installation

The main propelling machinery consists of one set of turbines, of the cross compound type, and double reduction gears, arranged so that either turbine can be operated ahead or astern independent of the other. The steam pressure at the turbine throttle is to be 200 pounds per square inch without superheat, and the set is to be capable of developing 4,000 brake horsepower when the propeller shaft is running at 90 revolutions per minute. A thrust bearing of the Kingsbury type is to be integral with the reduction gears.

The machinery installation also includes the following:

One main condenser of the cylindrical type, two pass, with a total cooling surface of 6,000 square feet.

One centrifugal double suction type circulating pump of 7,000 gallons per minute capacity against a 25-foot head.

One set of two air ejectors, with steam at 125 pounds per square inch pressure, each capable of maintaining a vacuum of 28 inches with a condenser of 6,000 square feet cooling surface handling 60,000 pounds of exhaust steam per hour.

One combination air separator and condensing tank.

Two turbo-pumps for condensate, each pump capable of handling 60,000 pounds of water per hour, to draw against a vacuum of 28 inches and discharge against a head of 30 feet.

Two lubricating oil pumps, 7 inches by 7 inches by 12 inches, of the vertical duplex double acting type.

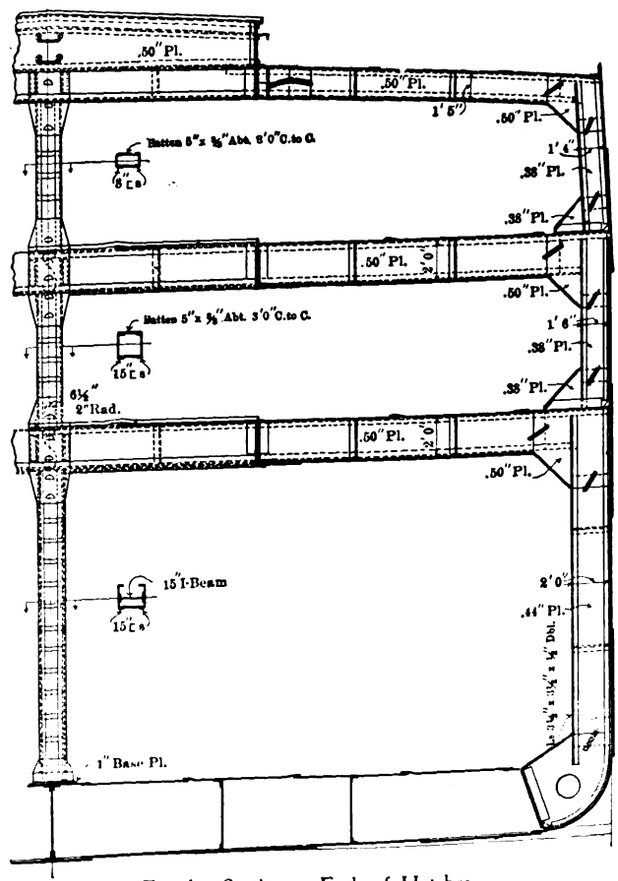

Fig. 1.—Section at Ends of Hatches

One circulating water pump for the lubricating oil system, 7 inches by 7 inches by 12 inches, of the vertical duplex double acting type.

Two oil coolers of 300 square feet cooling surface each.

One combination lubricating oil settling tank and filter with a filtering capacity of about 100 gallons per hour.

One feed and filter tank.

One fuel oil transfer pump, 8 inches by 8½ inches by 12 inches, vertical duplex double acting type.

Two fuel oil service pumps, 6 inches by 4 inches by 6 inches, of the horizontal duplex double acting type.

Two fuel oil heaters, each having the capacity to heat

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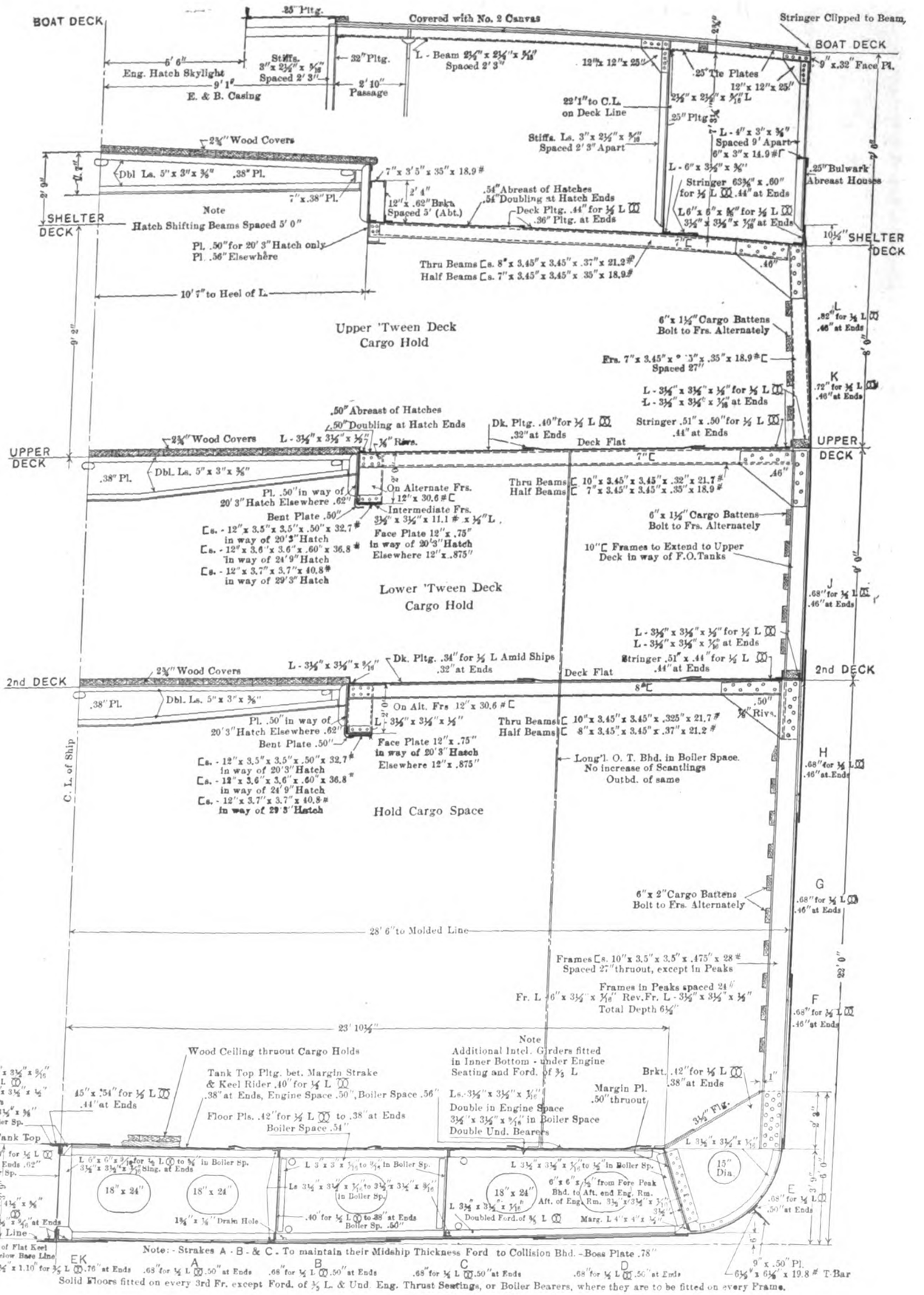
BOAT DECK
.25" Pltg.
Covered with No. 2 Canvas
Stringer Clipped to Beam
BOAT DECK
6' 6" Eng. Hatch Skylight
9' 1" E. & B. Casing
Stiffs. 3" x 2½" x 5/16" Spaced 2' 3"
32" Pltg.
2' 10" Passage
L - Beam 2½" x 2½" x 5/16" Spaced 2' 3"
12" x 12" x 25"
.25" Tie Plates
12" x 12" x 25"
2½" x 2½" x 5/16" L
22' 1" to C.L. on Deck Line
.25" Pltg.
9" x .32" Face Pl.
2¾" Wood Covers
Stiffs. Ls. 3" x 2½" x 5/16" Spaced 2' 3" Apart
L - 4" x 3" x 3/8" Spaced 9' Apart
6" x 3" x 14.9 # [
Dbl Ls. 5" x 3" x 3/8" .38" Pl.
7" x 3' 5" x 35" x 18.9 #
L - 6" x 3½" x 3/8"
.25" Bulwark Abreast Houses
Stringer 65 3/16" x .60" for ½ L .44" at Ends
L 6" x 6" x 3/8" for ½ L
3½" x 3½" x 7/16" at Ends
7" x .38" Pl.
12" x .62" Brkt. Spaced 5' (Abt.)
.54" Abreast of Hatches
.54" Doubling at Hatch Ends
Deck Pltg. .44" for ½ L
.36" Pltg. at Ends
SHELTER DECK
Note
Hatch Shifting Beams Spaced 5' 0"
Pl. .50" for 20' 3" Hatch only
Pl. .56" Elsewhere
Thru Beams ⊏s. 8" x 3.45" x 3.45" x .37" x 21.2 #
Half Beams ⊏s. 7" x 3.45" x 3.45" x .35" x 18.9 #
10½" SHELTER DECK
10' 7" to Heel of L
Upper 'Tween Deck Cargo Hold
6" x 1½" Cargo Battens Bolt to Frs. Alternately
Frs. 7" x 3.45" x .35" x 18.9 # ⊏ Spaced 27"
L .82" for ⅛ L .66" at Ends
K .72" for ⅛ L .46" at Ends
L - 3½" x 3½" x ½" for ½ L
L - 3½" x 3½" x 7/16" at Ends
.50" Abreast of Hatches
.50" Doubling at Hatch Ends
Dk. Pltg. .40" for ½ L .32" at Ends
Stringer .51" x .50" for ½ L .44" at Ends
2¾" Wood Covers
L - 3½" x 3½" x ½"
⅞" Rivs.
Deck Flat
UPPER DECK
UPPER DECK
.38" Pl.
Dbl. Ls. 5" x 3" x ⅜"
Pl. .50" in way of 20' 3" Hatch Elsewhere .62"
On Alternate Frs. 12" x 30.6 # ⊏
Intermediate Frs. 3½" x 3½" x 11.1 # x ½" L
Face Plate 12" x .75" in way of 20' 3" Hatch Elsewhere 12" x .875"
Bent Plate .50"
⊏s. - 12" x 3.5" x 3.5" x .50" x 32.7 # in way of 20' 3" Hatch
⊏s. - 12" x 3.6" x 3.6" x .60" x 36.8 # in way of 24' 9" Hatch
⊏s. - 12" x 3.7" x 3.7" x 40.8 # in way of 29' 3" Hatch
Thru Beams ⊏ 10" x 3.45" x 3.45" x .32" x 21.7 #
Half Beams ⊏ 7" x 3.45" x 3.45" x .35" x 18.9 #
6" x 1½" Cargo Battens Bolt to Frs. Alternately
10" ⊏ Frames to Extend to Upper Deck in way of F.O. Tanks
Lower 'Tween Deck Cargo Hold
J .68" for ½ L .46" at Ends
L - 3½" x 3½" x ½" for ½ L
L - 3½" x 3½" x 7/16" at Ends
Stringer .51" x .44" for ½ L .44" at Ends
2nd DECK
2¾" Wood Covers
L - 3½" x 3½" x 5/16"
Dk. Pltg. .34" for ½ L Amid Ships .32" at Ends
Deck Flat
2nd DECK
.38" Pl.
Dbl. Ls. 5" x 3" x ⅜"
Pl. .50" in way of 20' 3" Hatch Elsewhere .62"
On Alt. Frs 12" x 30.6 # ⊏
L - 3½" x 3½" x ½"
Face Plate 12" x .75" in way of 20' 3" Hatch Elsewhere 12" x .875"
Bent Plate .50"
⊏s. - 12" x 3.5" x 3.5" x .50" x 32.7 # in way of 20' 3" Hatch
⊏s. - 12" x 3.6" x 3.6" x .60" x 36.8 # in way of 24' 9" Hatch
⊏s. - 12" x 3.7" x 3.7" x 40.8 # in way of 29' 3" Hatch
Thru Beams ⊏ 10" x 3.45" x 3.45" x .325" x 21.7 #
Half Beams ⊏ 8" x 3.45" x 3.45" x .37" x 21.2 #
.50" ⅞" Rivs.
H .68" for ½ L .46" at Ends
Long'l. O. T. Bhd. in Boiler Space. No increase of Scantlings Outbd. of same
C. L. of Ship
Hold Cargo Space
6" x 2" Cargo Battens Bolt to Frs. Alternately
G .68" for ½ L .46" at Ends
28' 6" to Molded Line
Frames ⊏s. 10" x 3.5" x 3.5" x .475" x 28 # Spaced 27" thruout, except in Peaks
Frames in Peaks spaced 24"
Fr. L - 6" x 3½" x 5/16" Rev. Fr. L - 3½" x 3½" x ½"
Total Depth 6½"
F .68" for ½ L .46" at Ends
23' 10½"
Note
Additional Intcl. Girders fitted in Inner Bottom - under Engine Seating and Ford. of ⅓ L
Wood Ceiling thruout Cargo Holds
Tank Top Pltg. bet. Margin Strake & Keel Rider .40" for ½ L .38" at Ends, Engine Space .50", Boiler Space .56"
Floor Pls. .42" for ½ L to .38" at Ends Boiler Space .54"
Ls. - 3½" x 3½" x 7/16" Double in Engine Space 3½" x 3½" x 5/16" in Boiler Space Double Und. Bearers
Margin Pl. .50" thruout
Brkt. .42" for ½ L .38" at Ends
3½" Flgs.
L 3½" x 3½" x 5/16" for ½ L to 3½" x 3½" x ½" at Ends 3½" x 3½" x 7/16" in Boiler Sp.
.45" x .54" for ½ L .44" at Ends .62" in Boiler Sp.
Tank Top
L 6" x 6" x 5/16 for ½ L to ⅝" in Boiler Sp. 3½" x 3½" x 7/16 Sing. at Ends
L 3" x 3" x 7/16 to 5/16 in Boiler Sp.
L 3½" x 3½" x 7/16" to ½" in Boiler Sp.
6" x 6" x 7/16" from Fore Peak Bhd. to Aft. end Eng. Rm.
Aft. of Eng. Rm. 3½" x 3½" x 7/16"
15" Dia.
18" x 24"
18" x 24"
18" x 24"
1¾" x ¾" Drain Hole
Ls 3½" x 3½" x 7/16" to 3½" x 3½" x 5/16" in Boiler Sp.
.40" for ½ L to .38" at Ends Boiler Sp. .50"
L 3½" x 3½" x 5/16" Doubled Ford. of ⅝ L
Marg. L 4" x 4" x ½"
E .68" for ½ L .50" at Ends
L 4½" x 4½" x 7/16" for ½ L L 4½" x 4½" x 5/16" at Ends
Base Line
Note: - Top of Flat Keel Plate 0 1/16 Below Base Line
.51½" x 1.10" for ⅗ L .76" at Ends
EK
A .68" for ½ L .50" at Ends
B .68" for ½ L .50" at Ends
C .68" for ½ L .50" at Ends
D .68" for ½ L .50" at Ends
Note: - Strakes A - B - & C - To maintain their Midship Thickness Ford to Collision Bhd. - Boss Plate .78"
Solid Floors fitted on every 3rd Fr. except Ford. of ⅗ L. & Und. Eng. Thrust Seatings, or Boiler Bearers, where they are to be fitted on every Frame.
9" x .50" Pl.
6½" x 6½" x 19.8 # T Bar

Fig. 3.—Midship Section

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5,000 pounds of fuel oil per hour at 14 degrees Baumé from 90 to 250 degrees Fahrenheit.

Two fuel oil strainers, one 2½-inch duplex basket type suction strainer and one 2-inch duplex basket type discharge strainer.

Two feed pumps, 12 inches by 8 inches by 26 inches, of the vertical simplex type.

One 2-inch cast iron brass fitted injector suitable for 215 pounds per square inch working pressure.

One feed water heater to have the capacity to heat 64,000 pounds of water per hour from 90 to 215 degrees Fahrenheit.

One evaporator feed pump, 4½ inches by 4 inches by 4 inches, of the horizontal duplex double acting type.

Two cast iron shell evaporators of the submerged tube type, each to have the capacity to evaporate 25 tons of water every 24 hours.

One fresh water distiller to have a capacity of 2,000 gallons per 24 hours.

One auxiliary condenser of 800 square feet cooling surface, two pass, with shell and water heads of cast iron and fitted with the usual handholes, manholes, etc.

One fresh water pump, 5¼ inches by 4¾ inches by 5 inches, horizontal duplex double acting type.

One sanitary pump, 6 inches by 5¾ inches by 6 inches, of the horizontal duplex double acting type.

One fire and bilge pump, 10 inches by 8½ inches by 12 inches, of the vertical duplex double acting type.

One engine room bilge pump, 6 inches by 5¾ inches by 6 inches, of the horizontal duplex double acting type.

One fire and bilge hand pump, 6-inch by 5¼-inch single cylinder, double acting type, capable to lift 25 feet and discharge against a head of 100 feet.

One ballast pump, 10 inches by 12 inches by 12 inches, of the vertical duplex double acting type.

Boilers

Four single end Scotch boilers, 15 feet 10 inches internal diameter by 12 feet over the heads, will be installed to supply steam at 215 pounds per square inch working pressure. Each boiler has a total heating surface of 3,100 square feet and is provided with three furnaces having separate combustion chambers, which are fitted exclusively for oil burning. Forced draft will be provided by a blower having a capacity of 30,000 cubic feet of air per minute, driven by two single cylinder vertical engines.

A donkey boiler of sufficient size to furnish steam for starting fires in one main boiler is also provided.

Electric lights throughout the vessel will be supplied by two 10-kilowatt direct current generators.

Refrigeration for the cold storage rooms will be provided by a 2-ton refrigerating machine of the ammonia type.

Winches

Eight 8¼-inch by 10-inch and two 10-inch by 12-inch cargo winches will be located on the shelter deck in way of the cargo hatches. All cargo winches will be of the compound spur geared type having double horizontal reversible engines attached to the side housings.

One warping winch, 8¼ inches by 10 inches, single gear, fitted with two gypsy heads on an extension shaft and no drum will be located on the shelter deck aft.

Steering Gears

The main steering gear will be of the steam tiller type with a rack secured to the deck and double engines mounted on the tiller. The engines will drive through worm gearing to a pinion, which will engage the rack through a friction clutch. Steering control will be obtained by a hydraulic telemotor with polished brass controlling wheels and stands located in the pilot house and steering engine room aft.

An auxiliary hand steering gear, consisting of two large hardwood wheels with iron pedestal, is to be mounted on top of the after deck house. Power is transmitted by bevel gears, shafting, worm, worm wheel and pinion to a rack on a separate quadrant fitted to the rudder stock.

The windlass will be of the spur geared type with 10-inch by 10-inch horizontal reversible engines attached to the side housings, and having wildcats suitable for 2⅜-inch stud link chain. A warping shaft with a gypsy head on each end will be fitted on the after side of the windlass, clutches being provided to allow for independent operation of the windlass or gypsy. Hand operation is provided for by means of a ratchet arrangement fitted to the crank shaft.

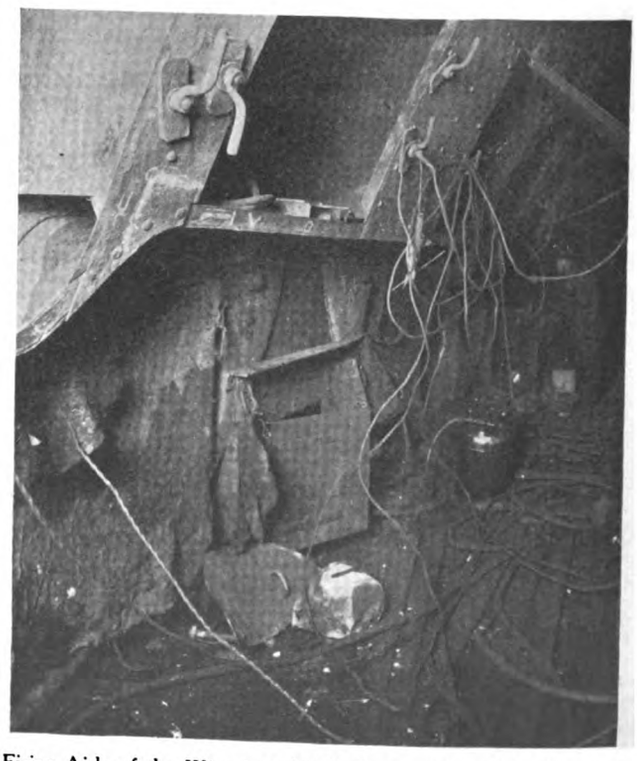
The propeller will be of the built up adjustable pitch type right hand screw, with four manganese bronze blades mounted on a cast iron hub and carried on a propeller shaft of 16¼ inches diameter.

These vessels are typical of the high class of vessels being added to America's merchant marine and will form a valuable addition to the fleet of the Shawmut Steamship Company.

Electric Welding in Marine Repairs

NOT long ago the *Winnebago* came into port with three of her Scotch boilers burned out. Eight of the sheets in the back connections of the combustion chambers were in bad shape and required the insertion of patches, each of which was about 2 feet 6 inches wide and 3 feet high.

Welding a patch of this size in a flat surface is difficult at best, and, although it may seem strange, cold weather increases the difficulty. Although the drop in atmospheric temperature at the lowest point reached during the winter



Firing Aisle of the *Winnebago* While Boilers Were Being Repaired

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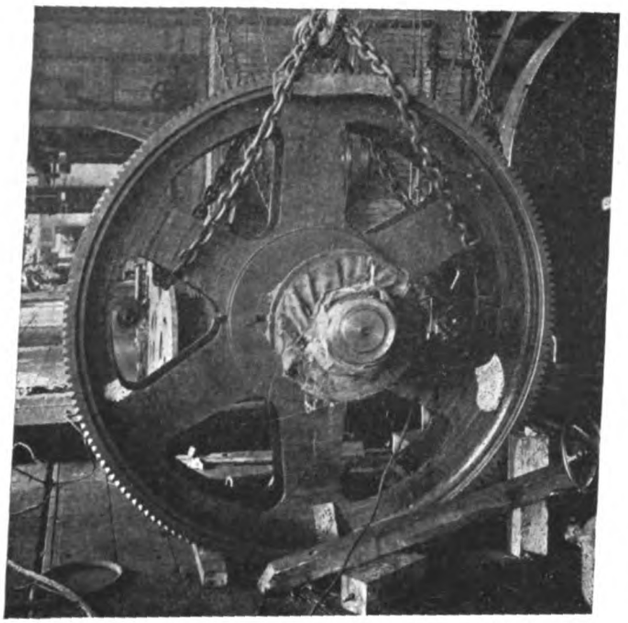


Eight-Ton Herring-Bone Gear of the *Belfort* as it Finally Appeared After the Second Welding

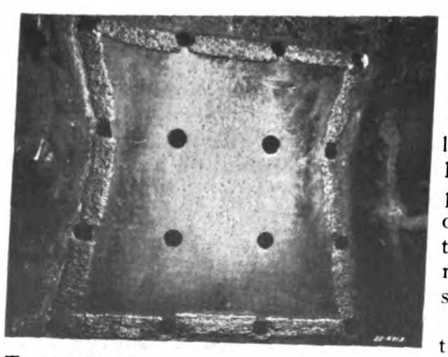
is only slight in comparison with the temperature of the electric arc, it proves very troublesome in keeping the metal at a welding heat.

In making the repairs to the *Winnebago* a welding barge, having compressors and generators installed, was brought alongside the ship to supply air to the pneumatic chipping hammers and power to the "weldcraft" apparatus of the Electric Welding Company of America, who carried out the work. To overcome the effect of low temperature in the boiler space it was necessary to preheat the work considerably.

The welds as completed were of the multiple string type, having been commenced at the top of the patch, continued down along the sides, and the bottom closed last.

It was necessary to weld the calking edges of some of the plates and around several of the rivets to make the boilers tight again and fit for service.

Another instance of the application of the "weldcraft" process to marine work occurred in the welding of one of the 8-ton herring-bone gears of the *Belfort*. The wheel in question, which is 9½ feet in diameter with a 24-inch face, of double-flange and double-spoke construction, had been broken in several places and welded. The original welds did not hold, however, so that it was necessary to cut out all the metal deposited on the spokes and reweld the cracks. As a result of cutting away so much metal the final welds were rather large, but these have not proved to be defective since they have been returned to service.



Typical Multiple String-Type Weld, Particularly Adapted to Flue Sheet Repairs

Incidentally, this repair saved scrapping the gear.

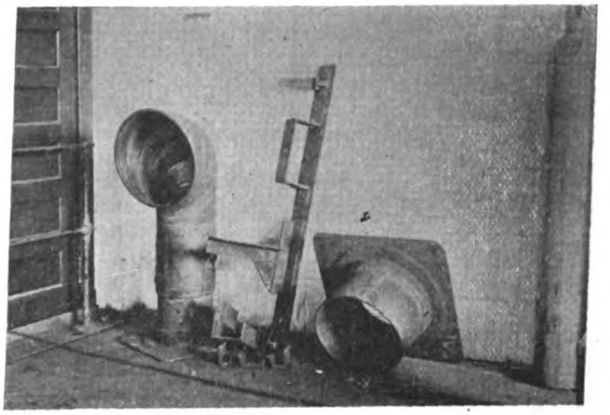


Fig. 1.—Left to Right: Portion of Welded Deck Rail Shown in Companion Picture; Welded Ventilator and Welded Ventilator Cowl, Ventilator Welded to Deck Plating; Welded Bulwark Splice; Combination Welds, Showing Welded-on Hinge, Pipe Hanger, Clip and Handle (Another Small Pipe Hanger Shown Below); Welded Deck Collar, Showing Welding at Deck Plate; Linde Oxygen Cylinder. All Welding by Oxy-Acetylene Process

Welded Joints on Ships

Low First Cost—Good Appearance—No Upkeep

GAS welding is more and more taking the place of riveting wherever metal joints are made. Especially is this so in shipbuilding where metal parts are exposed to salt air and moisture.

Every seafaring man knows how quickly a rim of rust will form along metal seams and around rivet heads even when painted. At such places the paint has to be gone over frequently because if it is neglected a rust scale will attack the metal and have to be scraped off by hand. Even landlubbers who go to sea know how common a sight is the ship's painter, with his little pot of red lead, eternally touching up crevices in the metal work, though this sight is not so familiar as it used to be. The reason is that many shipowners now have these troublesome joints reinforced by welding to make them weathertight and to better resist the vibrations and strains in the ships.

In new construction oxy-acetylene joints are recommended by representatives of the oxy-acetylene industries to take the place of riveted or combination riveted and welded joints, on the claim that they are both cheaper and stronger, besides being much neater in appearance. This

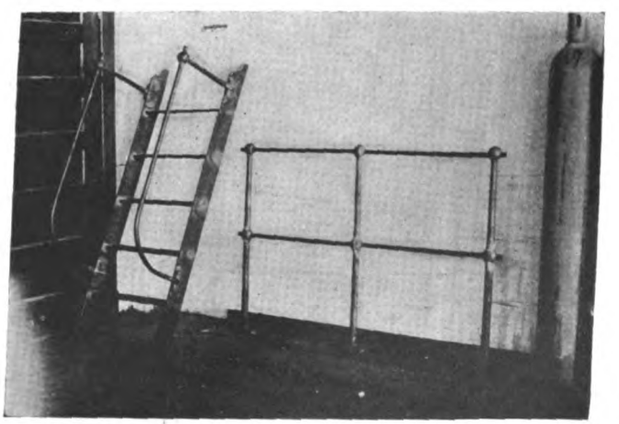


Fig. 2.—Left to Right: Ship's Ladder of Welded Construction by Oxy-Acetylene Process; Oxwelded Deck Rail, Welded to Deck Plating; Linde Oxygen Cylinder

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was reluctantly admitted recently at the Marine Exposition in New York, when an old Scotchman, an expert riveter, who visited the Oxweld Acetylene Company's booth, questioned the economy of welding on a ventilator cowl that was exhibited. His lowest estimate of the cost of riveting was $40, as against a welding cost, inclusive of overhead, nearly 30 percent lower. Another skeptic questioned the strength of a welded deck rail. Accordingly, a test was made, the stanchion being pounded with a heavy sledge until it was bent at right angles without parting the weld. It was then placed in a forge and restored to its proper form, bending back without damage to the weld. The skeptic was thus converted.

The chief reason that welding has not been more generally applied in the building of ships heretofore is the fact that it is, in its present stage of development, comparatively new. Marine engineers and constructors are very properly conservative and cautious in the adoption of new departures to displace old established practices. The considerable list of permitted welding applications in ship construction and repair, as now authorized by the American Bureau of Shipping and the United States Steamboat Inspection Service, has come only after conclusive proofs in service tests establishing the fitness of welding in each particular instance. This list is being gradually extended.

Determining the Quenching Points in the Heat Treatment of Steel by Means of the Critical Temperature Chart

IN developing various processes for heat-treating steel to impart certain qualities of hardness, toughness, tensile strength, grain structure and the like without changing the size or shape of the material, without the formation of scale or decarbonizing it, and with a minimum expenditure of labor, it has been found possible to utilize the known critical temperature record made by

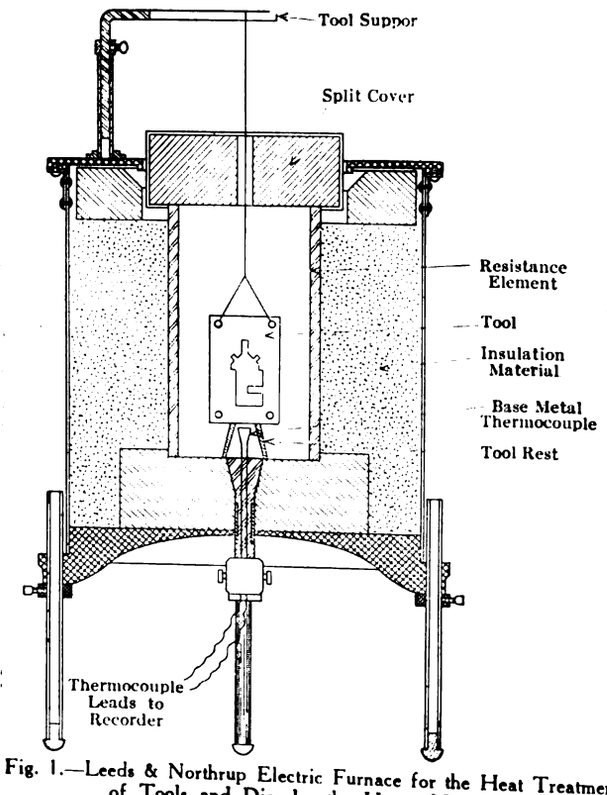

Fig. 1.—Leeds & Northrup Electric Furnace for the Heat Treatment of Tools and Dies by the Hump Method

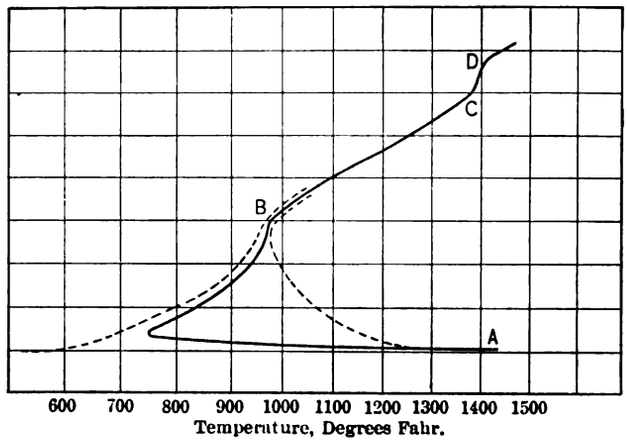

Fig. 2.—Curve Showing Temperature Changes in the Furnace and in the Tool

means of a suitable recording pyrometer to determine the proper quenching point. At the transformation or decalescence point a definite change of temperature occurs, and on a chart plotted from the temperatures of the steel, as drawn by the recording pyrometer, an offset or hump indicates the exact point of change. This fact has given the name of "hump method" to the heat-treating process recently developed by the Leeds & Northrup Company, Philadelphia, Pa.

Type of Furnace to be Used

The process may be carried out in an electric furnace similar to that shown in Fig. 1, in which the heating element consists of a vertical, cylindrical resistor surrounded by insulating material and a sheet iron jacket. The resistor rests upon a refractory block, which is supported by a cast iron bottom plate. A refractory cover is used to close the heating chamber at the top, while a cast iron top plate confines the loose insulating material filling the space between the resistor and the jacket. An iron-constantan thermocouple of bare No. 8 gage wire projects upwards from the center of the bottom refractory block. Covers are placed on the furnace so that the heating chamber is entirely inclosed, thus preventing the renewal of the atmosphere and protecting the work against oxidation and scaling.

The two instruments on which the value of the process depends are the thermocouple and a potentiometer of the curve drawing type, which gives a graphic record of the temperature of the thermocouple at all times. The slightest change in this temperature is properly indicated on the chart, and it is on this property that the efficiency of the method depends.

The Heating Process

The work to be treated is suspended by means of a wire from the tool support arm, Fig. 1, in such a manner that it practically rests on the thermocouple. At the moment when the work is introduced into the furnace the temperature of the latter may be, for example, about 1,400 degrees F., but the heat storage capacity of the furnace walls being small compared with that of the charge, the temperature of both thermocouple and furnace walls drops rapidly for a few hundred degrees, the current to the resistors being shut off during this time. Finally the temperature reaches a point of stability such as indicated by *B*, Fig. 2, to which temperature the charge has been heated. It is assumed that all parts of the furnace, thermocouple and charge are at temperature *B*, which is about 870 degrees F., and when the switch is closed and the

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temperature input regulated the rate of rise is constant.

The fact that all parts start from the same temperature at a point sufficiently far below the critical point, combined with the proper arrangement of the heating element with respect to the charge, insures, it is claimed, that all parts of the work will pass through the critical point simultaneously. This is desirable in order to avoid stresses and distortion that follow from unequal expansion or contraction.

When the work reaches the transformation point *C*, Fig. 2, an abrupt change occurs in the rate of heating, due to the increased capacity of the steel to store heat. When the transformation is completed at point *D*, the temperature again rises rapidly. The pause is clearly shown by the hump in the curve.

QUENCHING POINT

Before quenching, it is necessary to heat the work to a certain distance above, or for a certain time after, this point, the time or distance depending upon the mass and shape of the steel, the quenching medium employed and the qualities desired. The exact point for different materials must first be determined by experience or trial. The hump on the curve is used as a reference point, and by means of it a number of variables which occur in the present methods of heating are controlled.

In properly heating tools, such as punches or dies, a knowledge of certain variable elements must be known at all times. The point above the critical temperature at which the tool is to be quenched determines the property which the tool will have when it is removed from the quenching medium. The exact temperature, therefore, for quenching to impart a certain degree of hardness or a certain normal growth of grain, is very essential.

RATE OF HEATING CONTROLLED

If a tool is heated too fast, stresses are set up in the structure which will cause deformation and, possibly, breakage when placed in service. Slow heating will cause a change in the volume of the steel which entails a refinishing operation to bring it to the correct size. The potentiometer record eliminates both the fast and the slow heating possibilities.

Another point that is to be considered in treating steel is the necessity of preventing a change of atmosphere in the furnace. Any additional supply of oxygen after the heating has once been started causes scaling or decarbonization.

Quenching conditions are readily controllable once the critical temperature is known and the accuracy of the ordinary pyrometer is not depended upon for this temperature, the transformation being indicated by the hump on the curve.

All of the problems of hardening are by no means eliminated by the use of the "hump method," but the treatment seems to be more nearly under the control of the operator than in any other method so far developed.

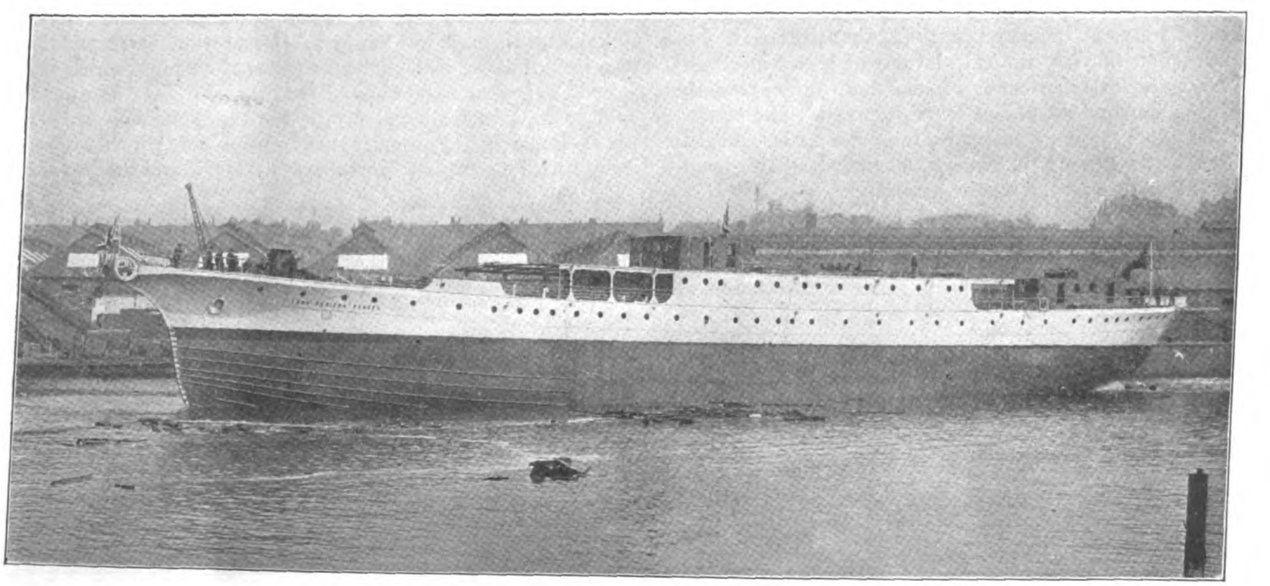
A New Cable Steamer

THE Fairfield Shipbuilding & Engineering Company, Limited, Govan, England, launched on May 29 the twin screw steamer *Lady Denison-Pender*, which has been built to the order of The Eastern Telegraph Company, Limited, London.

The vessel will be employed in the laying and repairing of telegraph cables. She is of the shelter deck type, with a long bridge and cruiser stern, 282 feet 8 inches by 38 feet 0 inches by 25 feet 0 inches depth to shelter deck, and 1,900 tons carrying capacity at a draft of 17 feet 6 inches, with a speed of 12 knots. There is accommodation for a total complement of 100, with hospital, surgery and cable testing rooms, a refrigerating chamber, a large chart room and the usual workshops and store rooms, the ventilation of which has received special consideration in view of long periods in a tropical climate. The ship is rigged as a two-masted schooner with two 5-ton derricks on the fore mast, and will be fitted with Marconi's latest system of wireless equipment.

There are three cable tanks having a total capacity of 20,830 cubic feet, which is equal to 600 nautical miles of cable. There are two sets of the latest type of cable working machinery with bow sheaves of an improved pattern.

The propelling machinery consists of two sets of three crank triple expansion engines with cylinders 15½ inches, 25 inches and 41 inches in diameter and 2 feet 6 inches stroke, supplied with steam by three single ended cylindrical boilers fitted with Howden's system of forced draft.



Launching of New Cable Steamer *Lady Denison-Pender*

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Ventilating Systems

A Graphic Method of Determining the Sizes of Mains and Ducts for Mechanical Ventilation

BY COMMANDER G. A. BISSET, CONSTRUCTION CORPS, U. S. N.

THE calculations outlined below are based on the General Specifications of the United States Navy, using a coefficient of friction for ordinary piping of .0001.

Certain standard conditions are assumed when determining the sizes of pipes, among which are the following:

A mean velocity over the area of the pipe of not less than 2,000 feet per minute, nor greater than 2,200 feet per minute.

The total head developed by the fan to correspond to a head of 2.2 inches of water or a pressure of 11.44 pounds per square foot.

The above conditions are for air with barometric pressure of 30 inches of mercury, a temperature of 70 degrees Fahrenheit and a relative humidity of 70 percent. Under these standard conditions a cubic foot of air weighs 0.07465 pound.

Losses

The total head available at any point in a main is equal to the total head developed by the fan minus the losses in the inlet and discharge piping of the fan up to that point. These losses usually consist of the following:

Loss due to friction of piping.
Loss due to elbows.
Loss due to converging tapers in piping.
Loss due to wire mesh on inlet cowl.

(The last loss is negligible and is omitted where the size of the mesh is approximately 1½ inches by 2 inches.)

Diagrams

By the proper use of the diagrams shown in Figs. 1 and 3, the calculations for vent piping are greatly simplified.

Loss due to friction of piping is obtained directly from Fig. 1, as follows:

Find the intersection of a diagonal line representing the diameter of pipe and the ordinate for air delivery in cubic feet per minute. The abscissa passing through this intersection gives the friction loss, per foot of pipe, in inches of water as indicated on the scale at the left.

In order to simplify the calculations of losses in elbows and to cover losses in bends of less than 90 degrees, the following table of losses has been prepared. The equivalent lengths of pipe given in the table are to be added to the length of pipe of the same size, including the length of the elbows measured on the centerline.

TABLE 1

Equivalent lengths of pipe for losses due to bends. Add to length of pipe of same size, including bends or elbows, for each bend or elbow.

Bend (Degrees)	Round Pipe. Equivalent Length in Feet
10	.65 d
20	1.31 d
30	1.97 d
40	2.63 d
45	2.95 d
50	3.28 d
60	3.94 d
70	4.60 d
80	5.25 d
90	5.91 d

Where d = diameter of round pipe in feet.

The loss of head due to converging cones in piping is taken as the mean friction loss of the tapered section, i. e., the length of the taper or cone times the mean of the friction loss per foot of pipe, at the beginning and end of the cone, for the same volume of air in the piping. The friction loss per foot of pipe for various volumes of air is found from the diagram.

Where the pipe is not round, Fig. 1 is used to determine the equivalent size of round pipe for the same loss per foot before using the above table. This is done by finding the point on diagram Fig. 1, where lines corresponding with the width and height of rectangular pipe intersect. From the intersection project a line horizontally till it meets one of the lines labeled $\sqrt{\frac{A^3}{S}}$, which will give the size of round pipe for equivalent loss. For example, if we have a rectangular pipe 8 inches by 16 inches, we find that size of round pipe for equal loss is 12¼ inches diameter.

Fig. 3 is used to determine the sizes of branches as hereinafter described.

Typical Example

The value of the diagrams to those having ventilation systems to design or check is illustrated by the following:

Assume a ventilating system as indicated in Fig. 2. The system consists of the inlet piping, a 4,000 cubic foot ventilating set with inlet and outlet dimensions as shown, a main, and eleven branches with a total delivery of 4,000 cubic feet per minute.

The losses in the inlet piping and main are found as follows:

(a) Loss in cowl A and mesh in inlet is neglected.

(b) Loss in cone B may be found from the diagram, Fig. 1, as follows:

Find the intersection of the vertical line, corresponding to a delivery of 4,000 cubic feet of air per minute, with the diagonal line for a pipe 29 inches in diameter. The horizontal line through the point of intersection corresponds to a loss of .0005 inch of water per foot of pipe, which is found at the left hand side of the diagram. The loss per foot of 21¼-inch diameter pipe for the same volume of air is found in the same manner and is .0024 inch. The length of the cone is 57 inches, or 4.75 feet, and the loss is

$$4.75 \times \frac{.0005 + .0024}{2} = .0069 \text{ inch.}$$

The total length of section C measured on the centerline is 19.7 feet, including two 90-degree elbows and a 30-degree bend.

From Table 1 above, the equivalent length of pipe for a 90-degree elbow is found to be 5.91 diameters, or 11.82 diameters for two elbows, and for a 30-degree bend 1.97 diameters. The equivalent length of pipe to be added is then

$$(11.82 + 1.97) \times \frac{21.25}{12} = 24.4 \text{ feet.}$$

The loss per foot of 21¼-inch pipe is .0024 inch of water, found as above, and the total loss in section C is .0024-inch (19.7 + 24.4) = .1058 inch.

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Friction Loss, Per Foot of Pipe, in Inches of Water.

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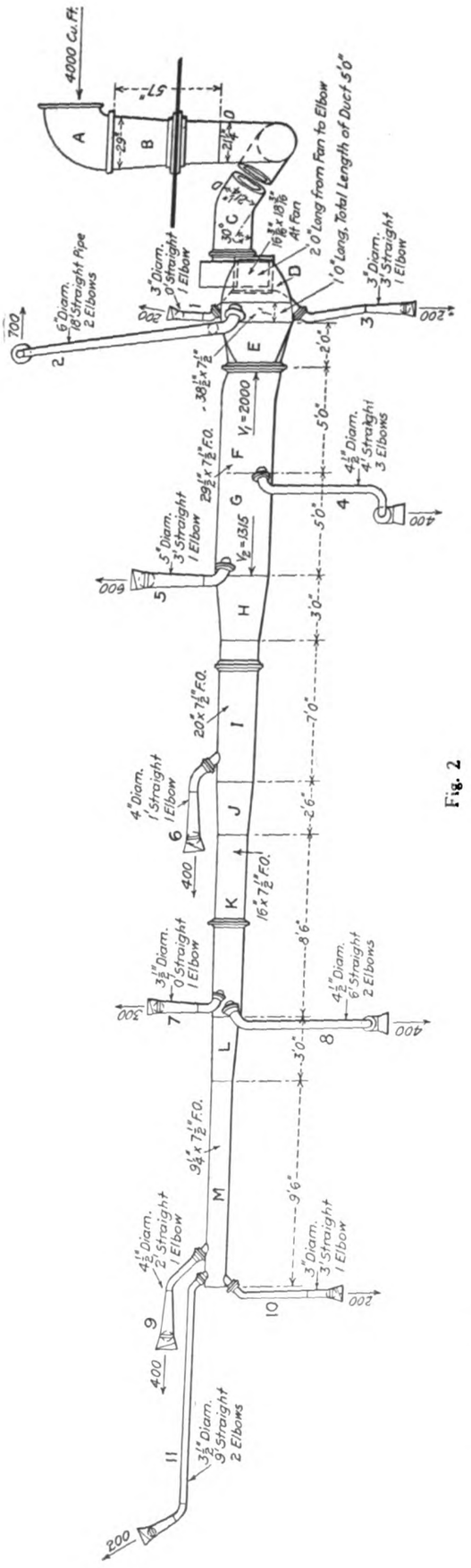

Fig. 2

Section *D* includes 2 feet of 16 3/16-inch by 18 3/16-inch pipe, an elbow 16 3/16 inches by 18 3/16 inches at one end and 38½ inches by 7½ inches at the other end, and 1 foot of 38½-inch by 7½-inch pipe. The loss per foot of 16 3/16-inch by 18 3/16-inch pipe for delivery of 4,000 cubic feet per minute is found as follows:

On the diagram, Fig. 1, find the intersection of diagonal lines for a width of 18 3/16 inches and a height of 16 3/16 inches. A horizontal line should be drawn through this point until it intersects one of the lines labeled $\sqrt{\frac{A^2}{S}}$. The intersection of the above horizontal line with the diagonal line for $\sqrt{\frac{A^2}{S}}$ shows the diameter of a round pipe which will have the same loss of head per foot as the rectangular pipe for the same volume of air. In this case the diameter of the equivalent round pipe is approximately 18.8 inches. The intersection of a diagonal line for this diameter with the vertical line for a volume of 4,000 cubic feet indicates a loss per foot of .0043 inch at the left hand side of the diagram. The loss per foot of 38½-inch by 7½-inch pipe is found in the same manner as above, except that, as this ratio of width to height of pipe is unusual, it is necessary to project the diagonal lines for these dimensions beyond the limits of the diagram. The equivalent round pipe is found to be 17½ inches in diameter, for which the loss per foot is .0063 inch at a volume of 4,000 cubic feet.

The loss in the 16 3/16-inch section is $2 \times .0043 = 0.0086$ inch.

The loss in the 38½-inch by 7½-inch section is $1 \times .0063 = .0063$ inch.

The loss per foot of straight line pipe which has a similar change in shape to that of the elbow will be the mean of the loss per foot for each size pipe, or

$$\frac{.0043 + .0063 \text{ inch}}{2} = .0053 \text{ inch.}$$

The equivalent length for loss due to bend, to be added to the length of the elbow measured on the centerline, is found by getting the equivalent round pipe (for a loss of .0053 inch per foot at 4,000 cubic feet delivery) and multiplying by the coefficient as given in Table 1.

Equivalent round pipe is 18 inches or 1.5 feet diameter. Equivalent length straight pipe is $5.91 \times 1.5 = 8.9$ feet.

Assume the length of the elbow on the centerline to be 4 feet. Then the loss in the elbow will be $(4 + 8.9) \times .0053 = .0684$ inch. Total loss in *D* is then $.0086 + .0063 + .0684 = .0833$.

Section *E* is 2 feet long, and the loss in head is the mean of the loss per foot of 38½-inch by 7½-inch and 29½-inch by 7½-inch pipe for 2,900 cubic feet times the length of *E*. The losses per foot of pipe are found from the diagram as outlined above, using the new dimensions and volume. The loss per foot of 38½-inch by 7½-inch pipe for 2,900 cubic feet is .0033 inch, and of 29½-inch by 7½-inch pipe for 2,900 cubic feet is .0058 inch. The loss in *E* is then

$$2 \times \frac{(.0033 + .0058)}{2} = .0091 \text{ inch.}$$

The loss in *F* is the loss per foot of 29½-inch by 7½-inch pipe for 2,900 cubic feet times the length plus the equivalent length for the offset. Assume the offset to consist of two 10-degree bends, then the equivalent length of pipe to be added is found as follows:

A 29½-inch by 7½-inch pipe is equivalent in loss to a 15.6-inch diameter round pipe from Fig. 1. Using Table 1:

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Equivalent length straight pipe = 1.30 × 15.6/12 = 1.7 feet.

a Branch Number	*b* Delivery, Cubic Feet per Minute	*c* Length Straight Pipe (Feet)	*d* Number of Elbows
1	200	0	1
2	700	18	2
3	200	3	1
4	400	4	3
5	600	3	1
6	400	1	1
7	300	0	1
8	400	6	2
9	400	2	1
10	200	3	1
11	200	9	2

The loss in *F* is then .0058 (5 + 1.7) = 0.039 inch.

The loss in *G* is found in the same manner as for *F*, except that the volume used will be 2,500 cubic feet and no offset is considered.

The losses in the remaining sections are found as outlined above. The work may further be simplified by first finding the losses per foot and total losses in the sections of each size for the proper volume and then with the losses per foot of each size pipe calculating the losses in the cone between the sections. This simplifies the work without affecting the results.

In tabular form the losses in the main and inlet piping will be as follows:

Volume of Air, Cubic Feet	Loss
(A) 4,000	Loss of head neglected
(B) 4,000	$\frac{(.0005 + .0024)}{2} \times 4.75 = .0069$ inch
(C) 4,000	.0024 (19.7 + 24.4) = .1058 inch
(D) 4,000	(2 × .0043) + (1 × .0063) + $\frac{(.0043 + .0063)}{2} \times (4 + 8.9) =$ .0833 inch
(E) 2,900	$\frac{(.0033 + .0058)}{2} \times 2 = .0091$ inch
(F) 2,900	.0058 (5 + 1.7) = .0390 inch
(G) 2,500	.0043 × 5 = .0215 inch
(H) 1,900	$\frac{(.0025 + .0059)}{2} \times 3 = .0126$ inch
(I) 1,900	.0059 × 7 = .0413 inch
(J) 1,500	$\frac{(.0037 + .0061)}{2} \times 2.5 = .0123$ inch
(K) 1,500	.0061 × 8.5 = .0519 inch
(L) 800	$\frac{(.00175 + .0064)}{2} \times 3 = .0122$ inch
(M) 800	.0064 × 9.5 = .0608 inch

If heating or cooling coils are included in the system the loss in pressure due to these coils should be considered in connection with the friction losses in piping and added thereto. The Sturtevant heaters used extensively on naval vessels have a resistance at rated volume, when by-passed, of approximately ½ inch of water, and when the air is passing through the heater of approximately 1 inch. When the volume of air passing through the heater is 30 percent less than the specified volume, as permitted under certain conditions, the resistance is reduced to approximately ½ inch.

Branches

The branches of the system are as follows:

e Angle of Branch (Degrees)	*f* Available Head at Branch (*hu*)	*g* $\sqrt{\frac{hu}{2.2}}$	*h* Delivery to Be Used on Fig. 3 *b/g*
30	2.0040″	.954	210
30	2.0040″	.954	734
30	2.0040″	.954	210
30	1.9559″	.943	424
30	1.9344″	.937	640
30	1.8805″	.924	433
30	1.8163″	.908	330
30	1.8163″	.908	441
30	1.7433″	.891	449
30	1.7433″	.891	224
30	1.7433″	.891	224

The available head at branch (*hu*) is found by subtracting losses in piping from pressure developed by fan (2.2 inches the standard total head).

In calculating the losses in branches, the net gain in static head due to coning the outlets so as to reduce the velocity may be combined with the loss due to ½-inch wire mesh on the outlet of the cone as follows:

Take d_1 as the diameter of the branch and d as the diameter of outlet of the cone. The net gain due to coning the outlet is equivalent to reducing the length of the branch by $27.2 \left(L - \frac{d_1^4}{d^4}\right)$ diameters. The loss due to ½-inch wire mesh on the outlet is equivalent to increasing the length of the branch by $14.7 \frac{d_1^4}{d^4}$ diameters. Hence:

$$27.2 \left(L - \frac{d_1^4}{d^4}\right) - 14.7 \frac{d_1^4}{d^4} =$$

decrease in length of branch due to combined effect with cone taper 1½ inches per foot. This formula gives a net gain in static pressure equivalent to decreasing the length of branch if the diameter of the outlet of the cone is more than 12 percent greater than the diameter of the branch. As this will usually be the case, and in order to give a small factor of safety as to delivery the effect of the cone and wire mesh may be neglected. The loss due to each elbow is equivalent to 8.3 diameters for round pipe. This loss is added to the length of straight pipe. If desired, the losses given in Table 1 may be used and added to the length of pipe of same size including elbows. The loss due to entrance is equivalent to 8.3 diameters for a 30-degree branch of round pipe.

The losses in the branches in equivalent lengths of straight pipe are as follows, based on the number of elbows and angle of branch given in a previous paragraph:

Branch Number	Loss Due to Elbow	Loss Due to Entrance	Total Loss Due to Elbows and Entrance to Branch
1	$8.3d_1$	$8.3d_1$	$16.6d_1$
2	$16.6d_1$	$8.3d_1$	$24.9d_1$
3	$8.3d_1$	$8.3d_1$	$16.6d_1$
4	$24.9d_1$	$8.3d_1$	$33.2d_1$
5	$8.3d_1$	$8.3d_1$	$16.6d_1$
6	$8.3d_1$	$8.3d_1$	$16.6d_1$
7	$8.3d_1$	$8.3d_1$	$16.6d_1$
8	$16.6d_1$	$8.3d_1$	$24.9d_1$
9	$8.3d_1$	$8.3d_1$	$16.6d_1$
10	$8.3d_1$	$8.3d_1$	$16.6d_1$
11	$16.6d_1$	$8.3d_1$	$24.9d_1$

The diameter of any branch may be found as outlined below for branch No. 2. For a trial diameter find from the diagram, Fig. 3, the diameter of a branch 18 feet long

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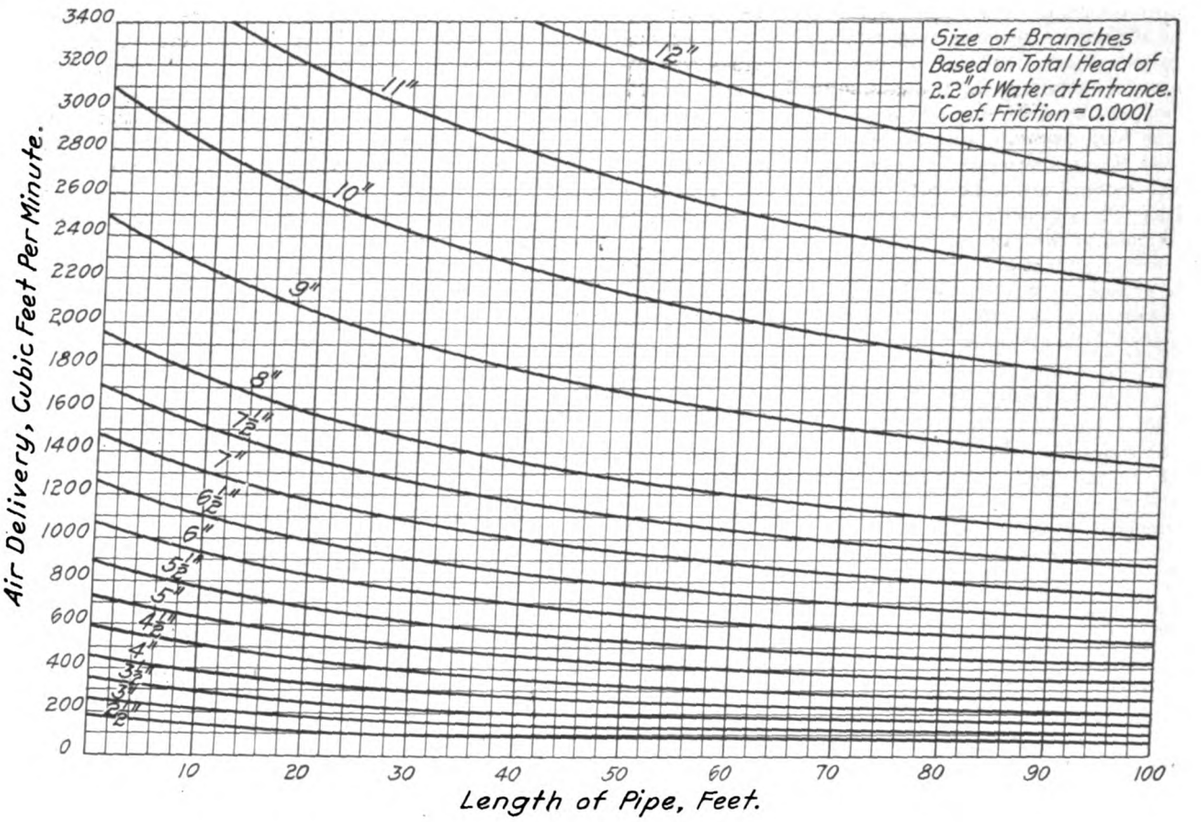

Fig. 3

which will deliver 734 cubic feet of air per minute. The diameter is 6 inches. The loss due to elbows and entrance to branch is equivalent to a length of pipe equal to $24.9d_1$. This corresponds to 12.45 feet of 6-inch pipe. The total length of branch to be used in finding the diameter from the diagram is 30.45 feet. For a delivery of 734 cubic feet per minute this length is found between the curves for 5½ and 6-inch branches; 6-inch is therefore the proper size to use. If the net gain in static pressure due to the cone were considered, it would approximately compensate for the losses due to elbows and entrance to branch so that the diameter indicated would be about 5½ inches. To find the diameter for outlet of cone for this branch, assume that the desired air velocity at the outlet of the branch is 1,000 feet per minute. A cone of sufficient diameter to deliver the required volume at this velocity should be fitted to the branch. If standard ½-inch wire mesh is fitted to the cone, the diameter of the cone should be sufficient to compensate for the restricted area due to the wire mesh. Take the reduction in area due to ½-inch mesh of 0.62-inch diameter wire to be 23 percent. Then to find the diameter of the outlet of the cone from diagram, Fig. 1, divide the required volume by the effective area (77 percent) and find the diameter of pipe for this volume at the required velocity. For branch No. 2 $\frac{700}{.77}$ = 910 cubic feet.

The diameter of pipe from the diagram corresponding to this volume at 1,000 feet per minute is approximately 13 inches.

The diameter of the other branches may be found in a similar manner, and will be as follows, neglecting the gain in pressure due to outlet cones:

Branch Number	Diameter of Branch (Inches)	Diameter of Outlet Cone for 1,000 Feet per Minute (Inches)
1	3	7
2	6	13
3	3	7
4	4½	9¾
5	5	12
6	4	9¾
7	3½	8½
8	4½	8½
9	4½	9¾
10	3	7
11	3½	7

If any system or branch supplies a space which may be under pressure, whether designed or due to inadequate facilities for escape of air, or if a system or branch exhausts from a space which may have a low pressure due to inadequate air supply, the difference between this high or low pressure and atmospheric pressure should be estimated in inches of water and treated as a loss of head. This loss of head may be handled in two ways. The available head (hu) at the inlet of the branch may be reduced by the amount of this loss before calculating the quantity of air to use in finding the size of branch from diagram, Fig. 3, or the loss may be reduced to the equivalent length of branch in feet by finding the loss of head per foot at the specified delivery for the trial diameter of branch and dividing this loss per foot into the loss due to pressure difference, this equivalent length to be added to the length of branch for finding the proper diameter. If a system or branch supplies a space having a low pressure or exhausts from a space having a high pressure, the difference between the high or low pressure and atmospheric pressure should be treated as a gain of head. In the case of a space with both supply and exhaust ventilating systems,

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the gain in head for the supply systems may be considered as the difference between atmospheric pressure and the low pressure due to exhaust systems if the supply systems were not in operation, and the gain in head for the exhaust systems as the difference between atmospheric pressure and the high pressure, due to the supply systems, if the exhaust systems were not in operation. Volumetric tests of such systems are to be made and the systems should be so designed as to deliver the specified volume of air without the aid of the gain in head produced by either supply or exhaust systems. The additional air supplied by any such system with both supply and exhaust systems in operation may be estimated by calculating the increased delivery due to the gain in head.

VENTILATION PIPING AND DETAILS
DESIGN POINTS

The following information covers points of importance in the actual design of piping and details.

The terminal velocities, as required by the Navy Department, are as follows:

Sick bay	500 feet per minute
Central and substations	800 feet per minute
Quarters and living spaces	1,000 feet per minute
Other places	1,500 feet per minute

All exhaust ventilation branch intakes should be designed to provide double the area which would be required for supply outlets of corresponding capacity.

It has not been found necessary to provide terminals with dampers, except in quarters and living spaces. In storerooms, passages, etc., no dampers are necessary and the terminals themselves need not have the adjustable features of the terminals in quarters.

All exhaust terminals should be provided with dampers and wire mesh guards.

Terminals in magazines (both powder and shell spaces) should be provided with wire mesh guards.

When a main subdivides into two branches of unequal size and resistance, it is well to provide an adjustable damper to aid in the subdivision of the air.

Branches should lead off from mains at an angle of about 30 degrees. This should be increased toward the ends of the mains, however, to 45 degrees where two branches lead off, or, in case of only one branch at end of main, the angle should be 90 degrees and the end of the main blanked off. The next to last branch might then well be made 45 degrees.

Where ventilation ducts pierce a watertight compartment, without delivering air to such compartment, the pipe should be constructed watertight. Such pipes, 6 inches and under, should be standard steel pipe; above 6 inches, the pipes should be made of 5-pound steel plate, lap-welded or riveted watertight.

Non-watertight ducts and pipes should be constructed of sheet steel galvanized and of the following thicknesses:

Size of Pipe (Diameter or Long Side)	Mils	U. S. Gage
6 inches and less	31	22
Above 6 inches and including 10 inches	37	20
Above 10 inches and including 12 inches	50	18
Above 12 inches	62	16

Portable sections and watertight covers should be provided wherever non-watertight ducts pierce watertight decks or bulkheads, also where watertight ducts terminate in a watertight compartment.

All branches supplying air to compartments below the lowest complete watertight deck should be watertight from that deck to the compartment supplied. This is to prevent the flooding of any compartment from another. Separate supply and exhaust ducts should be run for each compartment regardless of the additional holes through decks. Such supply and exhaust ducts may unite into a common pipe above the lowest complete watertight deck, however.

The radius to the center of pipe for all bends and elbows should be equal to 1½ diameters for round pipe and 1½ times the width, in the direction of radius, for square and rectangular pipe.

As the branches lead off, the size of a main should not be changed until sufficient air has been removed to reduce the velocity to a value between 1,200 and 1,500 feet per minute; then the main should be contracted with a taper of 1½ inches to the foot for round or square pipe or the equivalent for rectangular pipe until the area is so reduced that the velocity again reaches 2,000 to 2,200 feet per minute. The contraction should be made wherever necessary, but the final area of the main should be not less than four times the area of the last branch.

Welded Motorship Fullagar

The welded motorship Fullagar recently built by Cammell Laird & Company, Ltd., Birkenhead, England, is unique not only because of the fact that not a single rivet has been used in its construction, the hull being welded throughout, as are also the fuel, lubricating and water tanks, but also because it is the first vessel to be fitted with the Cammellaird-Fullagar type of main oil engine.

FOR many years, various processes of electric welding have been in use for effecting repairs in certain parts of boilers and in a few parts of the hulls of ships. It was always considered, however, that such welding was not to be relied upon in parts of a ship subjected to very heavy stresses. In the meantime, a new process of electric welding was devised, known as the Quasi-Arc system, which was used by Cammell Laird & Company, Ltd., on a battleship which had developed a serious fracture in her stern frame. The damaged casting was welded, and afterwards very severely tested at sea, with results so satisfactory that Cammell Laird & Company decided to experiment further with the new system of welding. Concerted action was taken by the shipbuilders and Lloyd's Register of Shipping, and after careful deliberation a series of tests was arranged to decide as far as possible on a small scale whether welded joints could be relied upon to replace riveting in a ship.

In the first place, the technical side of the problem only was dealt with, and in addition to obtaining information on tensile strength, the elastic properties of the welded metal, as well as its resistances to a continuous reversal of stresses, were investigated. In addition, chemical and microscopical tests were made. As a result, Lloyd's Register of Shipping gave its approval to the Quasi-Arc electric welding, and a set of rules for its application

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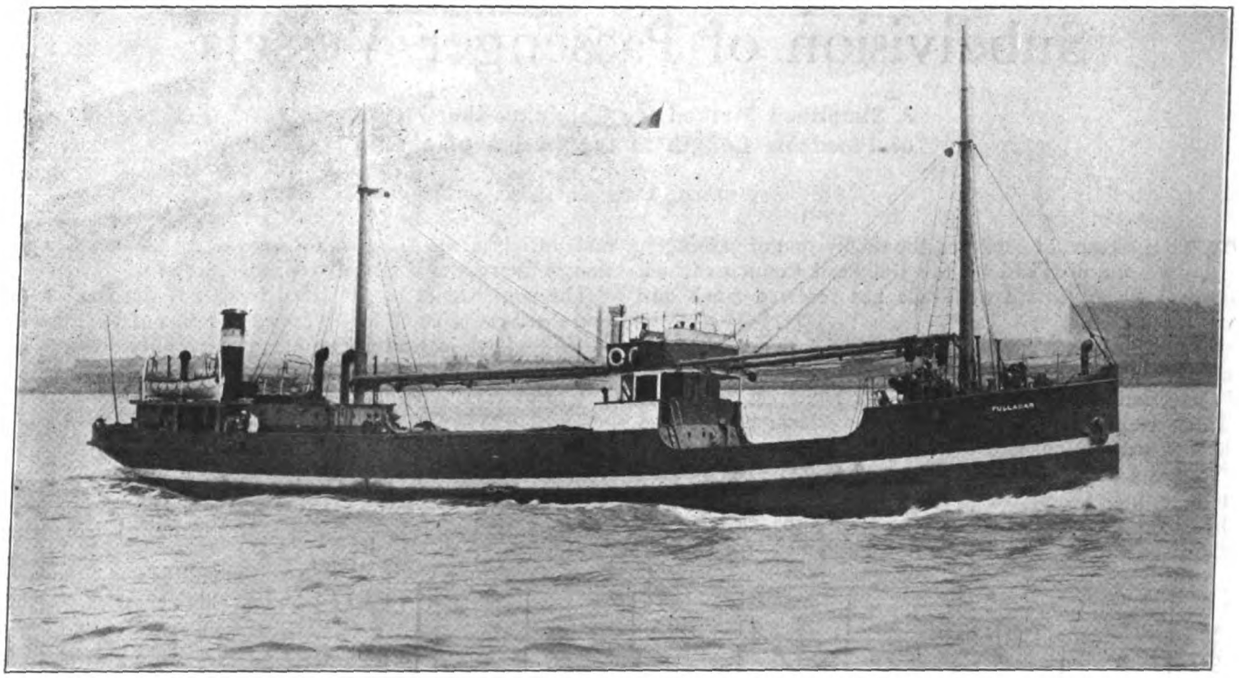

Welded Motorship *Fullagar* Fitted With "Camellaird-Fullagar" Oil Engine Built by Cammell, Laird & Company, Ltd., Birkenhead, England

is now embodied in the ordinary rules of this society.

Experimental tests, however well devised, cannot be as good as actual experience under working conditions. The next obvious step, therefore, was to build a welded ship. This required courage and faith, in spite of the satisfactory tests on a small scale. There were many things to be thought of, apart from the technical possibilities of welding. The ordinary type of riveted joint was not necessarily the best for welding work, so that special consideration had to be given to these. The problems of assembly and erection were altogether new. Men had to be trained as welders, and, of course, a new plant was necessary.

The first vessel to be built in accordance with this system of welding was the motorship *Fullagar,* which has the following molded dimensions:

Length	150 feet
Beam	23 feet 9 inches
Depth to main deck	11 feet 6 inches
Height of raised quarterdeck	4 feet
Draft	11 feet 4 inches
Deadweight capacity (about)	500 tons
Cargo capacity (about)	25,200 cubic feet
Brake horsepower (about)	450
Speed (about)	9½ knots

For carrying the cargo the vessel has one long hold served by two hatches. The propelling machinery is located aft with the fuel oil carried in side bunkers above the donkey boiler flat. The crew is berthed in the forecastle, the captain and mate amidships on the bridge, and the engineers abreast the engine room casing. The vessel is fitted with two masts, four derricks and three winches.

The hull is constructed of steel in the ordinary way and of usual ship qualities to Lloyd's tests. It is interesting to note that the majority of the steel was ordered neat, or, at any rate, with less working allowance than is usual. Several types of joints were used. Butts or ends of the shell plates are joined together by a continuous butt weld, this weld being backed by a light plate strap. In other cases plates are overlapped with a heavy continuous weld on both edges. The sides or edges of the shell plates are overlapped and continuously welded on both edges, one being a heavy and the other a light weld, or sometimes with a butt weld and strap, as described above. Other connections were made by light continuous welds for watertight work, intermittent or tack welding on edges of angle bars to plates or of plates to plates where non-watertight.

Propulsion of the welded motorship *Fullagar* is by a "Cammellaird-Fullagar" oil engine of 500 brake horsepower running at a speed of 100 to 120 revolutions per minute. The engine has four cylinders, each 14 inches diameter. Each piston has a stroke of 20 inches and works on the Diesel cycle. Air at a pressure of 1,000 pounds per square inch is used for injecting the fuel into the cylinders. A 3-stage air compressor is driven from the forward end of the crankshaft, the circulating pumps being arranged forward of that again, thus rendering the engine a self-contained propelling unit.

The savings in weight and space effected by this type of engine are now well known, and the builders' courage and foresight in adopting it have been amply rewarded by the satisfactory trials just carried out by the latest addition to Britain's fleet of motor vessels. The hull and machinery have been built by Cammell Laird & Company, Ltd., Birkenhead, under the supervision of Messrs. G. S. Goodwin & Company, consulting engineers, of Liverpool, and the vessel has been purchased by Messrs. Thos. & Jno. Brocklebank, Ltd.

On June 29 trials of the *Fullagar* were carried out in the river Mersey, the party on board consisting of engineers and shipbuilders from all parts of the country. The ease and quickness with which the engine could be maneuvered were especially noteworthy. From full speed ahead to full speed astern required only about 10 seconds, the engine easily starting action with full ahead way on the ship.

At about 11:40 P. M. on the same day she set off on her maiden trip to the Clyde. After getting clear of land extremely rough weather was encountered, and as this

(*Concluded on page 744.*)

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Subdivision of Passenger Vessels*

A Simplified Method for Obtaining the Curves of Floodable Length in the Design of a Ship

BY GEORGE WEBSTER, M. SC.

THE method of obtaining the subdivision of passenger vessels proposed by the Bulkhead Committee and adopted by the Board of Trade has received much adverse criticism.

Objections have been raised not only to the intricate and laborious nature of the calculations, especially the "correction for form," but also to their indirect character. The permissible draft of a ship can seldom be obtained by one calculation, and generally has to be obtained by "trial and error," which means repeating the calculations two or three times. In addition, further time is taken up by the Board of Trade in examining the calculations. Great advantage would therefore be gained if a simpler, quicker and more direct method of obtaining the flooding curve for a ship could be devised.

With this object in view, it is necessary to consider the variables which affect the flooding calculations.

The floodable length l at any point in the ship has been shown by the Bulkhead Committee to be dependent upon:

(1) Freeboard ratio $= \frac{\text{freeboard}}{\text{draft}}$.

(2) Permeability.

(3) Sheer ratio $= \frac{\text{sheer}}{\text{draft}}$.

(4) Block coefficient.

(5) Form of ship.

(6) Length of ship.

If the floodable length is expressed as a percentage of the length of the ship, item (6) disappears. Of the remaining five variables, the last one, i. e., "form of ship," is the most difficult to take account of, and if this could be omitted the problem would be considerably simplified.

The Standard Curves prepared by the Bulkhead Committee take account of the first four of these variables, and introduce the "Correction for Form" as a modification to the results obtained from the curves.

The work would be simplified further if the freeboard and sheer ratios could be expressed in terms of the known quantity *depth* instead of the unknown quantity *draft*.

It is now necessary to examine the effect on the floodable length of variations in each of the above variables.

Floodable Length and Freeboard Ratio

A series of cross curves of floodable length on a base of freeboard ratio $\left(\frac{\text{freeboard}}{\text{draft}}\right)$ were obtained from the Bulkhead Committee's Standard Curves, and a similar series on the base of $\frac{\text{freeboard}}{\text{depth}}$ were also plotted.

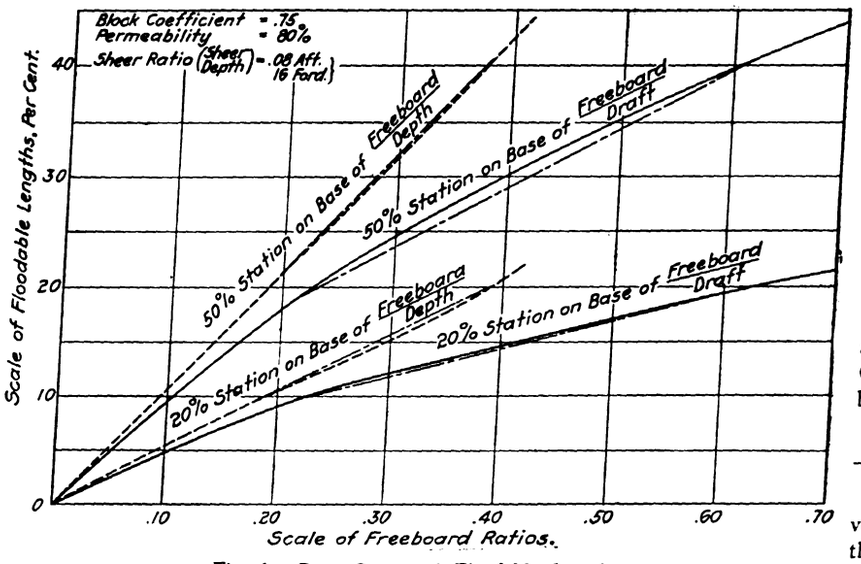

Fig. 1.—Cross Curves of Floodable Lengths

The curves are somewhat of the form shown in Fig. 1. For freeboard ratios greater than 0.20, the curves are of a very flat nature, especially if plotted on a base of $\frac{\text{freeboard}}{\text{depth}}$, when they approach very nearly to straight lines. Consequently, if the floodable length be assumed to vary directly with $\frac{\text{freeboard}}{\text{depth}}$, no great error will be involved, and whatever small error there is, it will be less than would be incurred if the floodable length was taken to vary directly with $\frac{\text{freeboard}}{\text{draft}}$.

The freeboard ratios of a number of vessels were examined and it was found that values of $\frac{\text{freeboard}}{\text{depth}}$ less than 0.18 or greater than 0.38 (equivalent to $\frac{\text{freeboard}}{\text{draft}}$ of 0.219 and 0.613) are seldom, if ever, met with in practice. It therefore appears that the floodable length can without very great error be assumed to vary directly with the freeboard ratio, provided the latter is expressed in terms of the depth instead of the draft $\left(\text{i. e., } \frac{\text{freeboard}}{\text{depth}}\right)$ and is within the above-mentioned limits.

Floodable Length and Permeability

The Standard Curves already referred to, prepared by the Bulkhead Committee, give floodable lengths for two extreme permeabilities, viz., 60 percent and 100 percent. Floodable lengths for intermediate permeabilities are ob-

* From a paper read before the Institution of Naval Architects, Liverpool, July 7, 1920.

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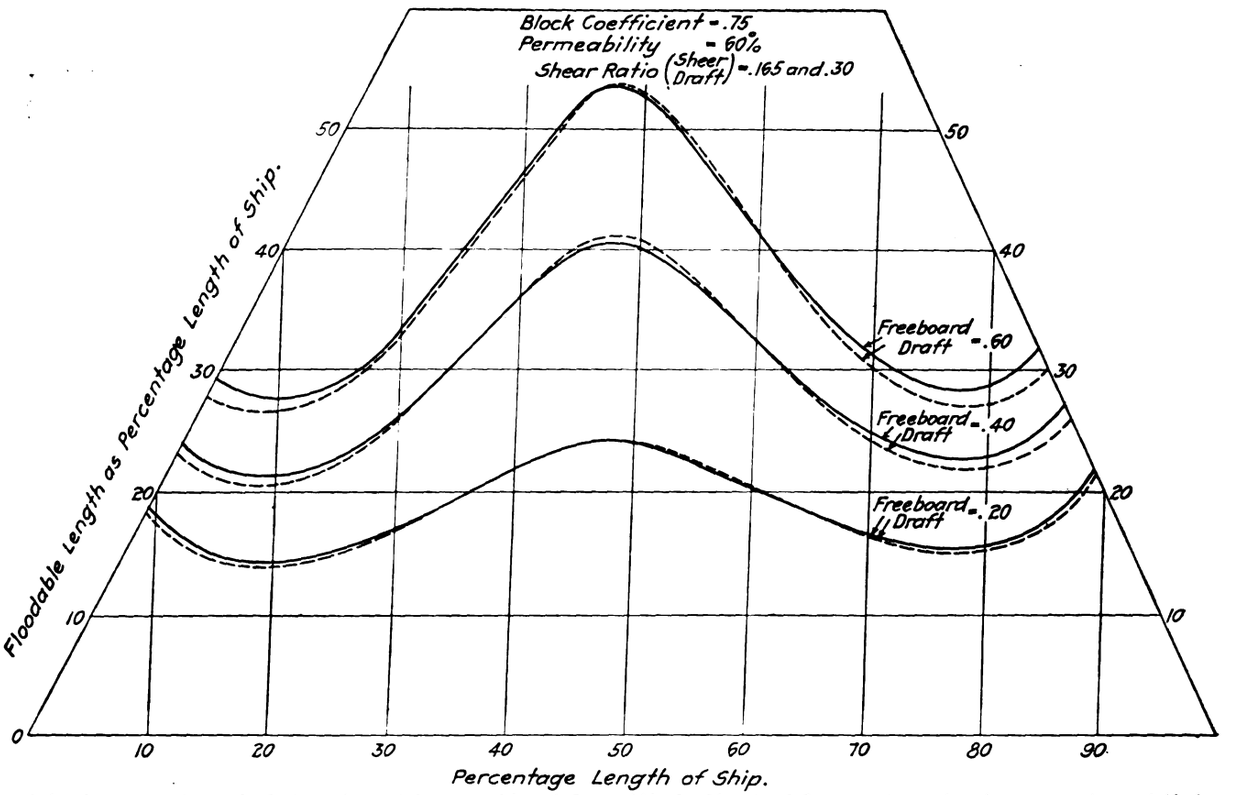

Actual curves shown in full. Obtained from Bulkhead Committee's Standard Curves. Approximate curves shown dotted. Obtained by assuming floodable length varies inversely with permeability.

Fig. 2.—Typical Flooding Curves

taind by assuming that the differences in floodable lengths between the two sets of curves vary in the inverse ratio of the differences in the permeabilities.

For example, if l_1 and l_2 be the floodable lengths for permeabilities of 60 percent and 100 percent respectively, then the floodable length l_u for any permeability u intermediate between 60 percent and 100 percent is given by:

$$l_u = l_2 + \left[(l_1 - l_2) \frac{\left(\frac{1}{u} - \frac{1}{100}\right)}{\left(\frac{1}{60} - \frac{1}{100}\right)} \right]$$

A reduction in labor would be obtained if the results could be derived from one set of diagrams instead of two. This might be arranged if the floodable length can be assumed to vary inversely with the permeability. Then

$$l_u = l_1 \times \frac{60}{u},$$

or

$$l_u = l_2 \times \frac{100}{u}.$$

Investigations of a number of cases have been made in order to ascertain the error involved when this assumption is made. Fig. 2 is a typical example, the full curves giving the floodable lengths for 60 percent permeability being obtained direct from the Bulkhead Committee's diagrams. The dotted curves give approximate floodable lengths for 60 percent permeability, and were obtained by assuming the floodable lengths to vary inversely with the permeability between 80 percent and 60 percent, i. e., the floodable lengths for 80 percent permeability were obtained from the Bulkhead Committee's diagrams and were modified in the ratio of 80 to 60.

It is seen that towards the ends of the ships the approximate method gives results which are less than the actual (i. e., they err on the safe side), while towards amidships there is practically no difference in the two curves. Consequently, since the permeability in the majority of ships lies between about 65 percent and 85 percent, and since freeboard ratios $\left(\frac{\text{freeboard}}{\text{draft}}\right)$ much greater than 0.40 are unusual, it is seen that no great error will be introduced if flooding ordinates for 80 percent permeability only are given, and floodable lengths for any other permeability are obtained by modifying these given ordinates in the inverse ratio of the permeabilities.

The permeability of machinery spaces is laid down by the Bulkhead Committee to be 80 percent (except in motor vessels, when it is 85 percent), and thus the midship portion of the flooding curve can be obtained very quickly if, as proposed, 80 percent is adopted as the basis permeability.

Floodable Length and Sheer Ratio

The block coefficient, to some extent, affects the errors involved, when the above assumptions for permeability are made, but not to a very marked degree. The errors are least when the block coefficient is between about 0.65 and 0.75, but with the more unusual block coefficients lying in the neighborhood of 0.55 and 0.85 the errors will be slightly greater. Block coefficients greater than 0.80 or less than 0.60 are seldom, if ever, met with in practice, and if the straight line law for permeability be assumed within these limits, no serious error will be involved.

It has been shown above that it will be convenient to

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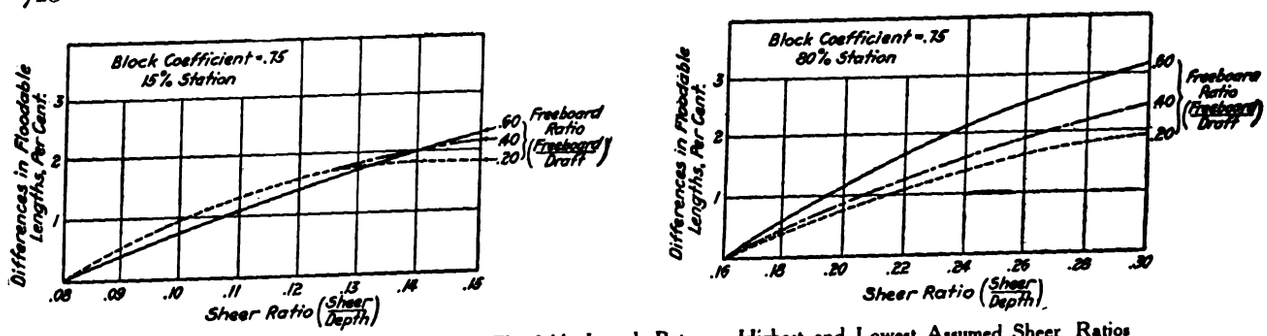

Fig. 3.—Curves Showing Variation in Floodable Length Between Highest and Lowest Assumed Sheer Ratios

express the freeboard ratio in terms of the depth instead of draft, and therefore it will be an advantage to express the sheer ratio in terms of the same quantity.

With a view to ascertaining reasonable maximum and minimum values, examination of these ratios has been made for a number of vessels, and values have also been obtained by using the standard sheers given by the Load Line Committee. It is found that reasonable ranges of sheer ratio $\left(\frac{\text{sheer}}{\text{depth}}\right)$ might be taken to be 0.08 to 0.15 aft and 0.16 to 0.30 forward. Sheers giving ratios outside these limits are very exceptional.

Curves showing the variation in the floodable lengths for variations in sheer ratios between the above limits were obtained for block coefficients between 0.55 and 0.85, and for the above suggested limits of freeboard ratios.

Fig. 3 shows a typical example, and as these curves are of a very flat nature, no great error will be involved if the floodable length is assumed to vary directly with the sheer ratio $\left(\frac{\text{sheer}}{\text{depth}}\right)$ between the highest and lowest assumed limits.

Floodable Length and Block Coefficient.

Examination of the effect of block coefficient on floodable length showed that while an increase in the block coefficient increases the length of the flooding ordinates amidships, it reduces the length of those towards the end, and it does not appear possible to obtain any simple relation between these two items.

Summary of Conclusions

By assuming that the floodable length varies:

(1) Directly with the freeboard ratio $\left(\frac{\text{freeboard}}{\text{depth}}\right)$ between the limits of 0.18 and 0.38;

(2) Inversely with the permeability;

(3) Directly with the sheer ratio $\left(\frac{\text{sheer}}{\text{depth}}\right)$ between the limits of 0.08 and 0.15 aft, and 0.16 and 0.30 forward:

it is seen that no great error will be involved and considerable advantage will be gained, as it will be possible to simplify considerably the method of obtaining the floodable lengths.

Suggested Table for Obtaining Flooding Ordinates

As will be seen later, it is also a great advantage to express the freeboard and sheer ratios in terms of the known quantity depth instead of the unknown quantity draft, for it eliminates the necessity of having to obtain the draft by the "trial and error" method.

It is now necessary to ascertain a convenient method of tabulating the flooding ordinates when the above assumptions are made.

Fig. 4 shows a straight line drawn through a cross curve of floodable lengths on a base of freeboard ratio $\left(\frac{\text{freeboard}}{\text{depth}}\right)$. The proposal is to assume that the straight line $A\ B$ gives the required flooding ordinates instead of the curve $E\ F$.

If the line $A\ B$ is produced to meet the axis of X in C, the equation of the line is given by

$$y = m\ (a + x),$$

where m is the slope of the line, and a is the intercept $(C\ O)$ of the line on the axis of X beyond the origin.

Thus any ordinate of the cross curve of floodable lengths represented by the straight line $A\ B$ can be obtained if the values of m and a are known.

Cross curves of floodable lengths on a base of freeboard ratios $\left(\frac{\text{freeboard}}{\text{depth}}\right)$ were obtained for the stations in the ship given by the Bulkhead Committee, for a permeability of 80 percent, for block coefficients varying between 0.60 and 0.80 and for the highest and lowest assumed sheer ratios. Straight lines were then drawn through these curves between the above-mentioned limits of freeboard ratio in such a manner that the errors involved when the floodable length is obtained from the straight line instead of the curve are in every case the minimum possible. Variations in one quantity were set off against fluctuations in other quantities, and in many instances errors were in this manner completely eliminated.

From these graphs values of m and a were obtained, and these are shown in Table I, from which it is possible to obtain a curve of floodable lengths for a permeability of 80 percent for any condition within the assumed limits by the formula:

$$l = m\ (a + f),$$

where l is the percentage floodable length; f, the freeboard ratio, is the ratio of the *freeboard* (measured from the subdivision load line to the lowest point of the margin line) to the *depth* (measured from the top of keel to the

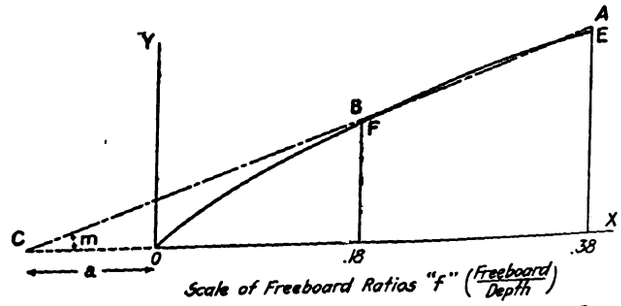

Fig. 4.—Diagram Showing Straight Line Drawn Through Cross Curve of Floodable Lengths

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Table I.—Floodable Length Factors.

AFTER BODY

Block Coefficient.	Sheer Ratio.	A.T. m.	A.T. a.	15 percent m.	15 percent a.	20 percent m.	20 percent a.	30 percent m.	30 percent a.	40 percent m.	40 percent a.	45 percent m.	45 percent a.
0.60	0.15	41.2	0.275	57.4	0.077	57.7	0.045	66.9	0.021	96.3	—0.013	104.9	—0.020
	0.08	40.0	0.250	55.9	0.044	55.2	0.018	63.7	0.001	92.0	—0.017	104.3	—0.022
0.62	0.15	40.9	0.268	56.6	0.072	56.8	0.044	66.0	0.024	95.3	—0.008	105.1	—0.017
	0.08	39.4	0.248	54.9	0.041	54.2	0.017	62.8	0.004	91.2	—0.013	104.3	—0.019
0.64	0.15	40.6	0.261	55.9	0.067	55.9	0.043	65.1	0.027	94.4	—0.004	105.2	—0.014
	0.08	39.0	0.244	53.9	0.037	53.2	0.016	62.1	0.006	90.4	—0.009	104.3	—0.016
0.66	0.15	40.4	0.253	55.2	0.062	55.1	0.041	64.4	0.029	93.6	0.000	105.2	—0.012
	0.08	38.6	0.238	53.1	0.033	52.4	0.015	61.5	0.008	89.6	—0.005	104.2	—0.013
0.68	0.15	40.2	0.245	54.5	0.056	54.4	0.039	63.8	0.032	92.8	0.004	105.2	—0.009
	0.08	38.3	0.229	52.2	0.028	51.6	0.014	61.0	0.009	88.9	—0.001	104.1	—0.010
0.70	0.15	40.0	0.235	53.9	0.051	53.6	0.037	63.3	0.035	92.1	0.008	105.2	—0.006
	0.08	38.1	0.219	51.5	0.023	50.9	0.013	60.7	0.011	88.2	0.003	104.1	—0.007
0.72	0.15	39.9	0.225	53.2	0.046	53.0	0.036	62.9	0.038	91.5	0 012	105.2	—0.003
	0.08	38.0	0.207	50.7	0.018	50.2	0.012	60.6	0.012	87.6	0.007	104.2	—0.004
0.74	0.15	39.8	0.215	52.6	0.042	52.3	0.036	62.6	0.041	91.1	0.016	105.4	0.000
	0.08	38.0	0.194	49.9	0.015	49.5	0.012	60.5	0.014	87.2	0.011	104.4	—0.001
0.76	0.15	39.7	0.203	51.9	0.040	51.7	0.038	62.5	0.044	90.9	0.020	105.7	0.002
	0.08	38.0	0.180	49.1	0.013	49.0	0.013	60.5	0.017	86.9	0.015	104.7	0.001
0.78	0.15	39.7	0.190	51.2	0.040	51.1	0.041	62.5	0.048	90.9	0.023	106.1	0.005
	0.08	38.1	0.166	48.2	0.013	48.4	0.015	60.5	0.020	86.7	0.018	105.1	0.004
0.80	0.15	39.8	0.176	50.3	0.041	50.5	0.046	62.6	0.052	91.0	0.027	106.7	0.008
	0.08	38.2	0.152	47.2	0.015	47.9	0.018	60.6	0.024	86.7	0.021	105.7	0.006

FORE BODY.

Block Coefficient.	Sheer Ratio.	50 percent m.	50 percent a.	60 percent m.	60 percent a.	70 percent m.	70 percent a.	80 percent m.	80 percent a.	85 percent m.	85 percent a.	F.T. m.	F.T. a.
0.60	0.30	98.5	—0.017	72.9	0.012	55.7	0.048	56.3	0.080	61.7	0.0115	40.2	0.379
	0.16	97.0	—0.017	68.4	0.006	51.2	0.035	49.1	0.077	56.9	0.091	36.8	0.379
0.62	0.30	99.4	—0.015	74.2	0.012	56.0	0.045	55.4	0.077	60.8	0.110	40.1	0.368
	0.16	98.2	—0.015	69.5	0.007	51.4	0.032	48.4	0.073	55.8	0.087	36.8	0.365
0.64	0.30	100.3	—0.012	75.3	0.013	56.2	0.044	54.7	0.074	59.9	0.104	39.9	0.359
	0.16	99.2	—0.012	70.4	0.009	51.6	0.031	47.8	0.069	54.6	0.083	36.8	0.353
0.66	0.30	101.1	—0.009	76.2	0.015	56.3	0.044	53.9	0.071	59.0	0.098	39.6	0.350
	0.16	100.2	—0.010	71.0	0.012	51.8	0.031	47.3	0.065	53.4	0.079	36.7	0.341
0.68	0.30	101.9	—0.005	76.9	0.018	56.4	0.046	53.2	0.068	58.2	0.093	39.4	0.342
	0.16	101.0	—0.006	71.6	0.015	52.0	0.032	46.7	0.062	52.3	0.076	36.6	0.330
0.70	0.30	102.6	—0.002	77.6	0.022	56.6	0.048	52.5	0.066	57.3	0.087	39.1	0.333
	0.16	101.8	—0.004	72.1	0.019	52.2	0.034	46.2	0.059	51.2	0.072	36.5	0.319
0.72	0.30	103.5	0.001	78.4	0.025	56.9	0.050	52.0	0.065	56.4	0.082	38.8	0.324
	0.16	102.7	—0.001	72.8	0.023	52 5	0.037	45.8	0.057	50.1	0.059	36.4	0.308
0.74	0.30	104.4	0.004	79.5	0.028	57.4	0.053	51.5	0.064	55.6	0.076	38.6	0.314
	0.16	103.6	0.002	73.9	0.026	52.9	0.039	45.4	0.056	49.0	0.066	36.3	0.296
0.76	0.30	105.6	0.006	81.0	0.029	58.2	0.056	51.0	0.064	54.9	0.070	38.4	0.303
	0.16	104.8	0.004	75.3	0.028	53.6	0.042	45.1	0.054	48.0	0.062	36.2	0.283
0.78	0.30	107.0	0.008	83.1	0.030	59.4	0.059	50.7	0.065	54.2	0.065	38.4	0.288
	0.16	106.3	0.006	77.2	0.028	54.5	0.046	44.9	0.054	47.1	0.059	36.2	0.269
0.80	0.30	108.6	0.009	85.6	0.030	60.9	0.062	50.4	0.066	53.5	0.059	38.5	0.272
	0.16	108.0	0.007	79.5	0.028	55.6	0.049	44.8	0.054	46.3	0.055	36.2	0.253

This Table applies to all cases where—
1. The freeboard ratio varies from 0.18 to 0.38. 2. The sheer ratio varies from 0.16 to 0.30 forward and from 0.08 to 0.15 aft. 3. The block coefficient varies from 0.60 to 0.80.

NOTE—For the forward and after terminals the ordinate of the flooding curve as given by the formula must be plotted on a vertical line situated at a distance from the particular terminal equal to one-half the floodable length given by the formula for a permeability of 80 percent.

lowest point of the margin line). The margin line is parallel to the bulkhead deck at side line and 3 inches below the upper surface of that deck; m and a are factors obtained from the table.

Block coefficient is the displacement volume to molded lines, divided by length on the subdivision load line multiplied by molded breadth and by draft from top of keel. *Sheer ratio* (forward or aft) is the ratio of the *sheer* of the margin line at the ends (measured from a line drawn through the lowest point of the margin line parallel to the subdivision load line) to the *depth* (measured from the top of keel to the lowest point of the margin line).

Values of m and a for block coefficients or sheer ratios intermediate between those given in the table are obtained by linear interpolation, and, since it has been shown that the floodable length can be taken to vary inversely with the permeability, the floodable length for any permeability is given by:

$$l = \frac{80}{u} [m\ (a + f)],$$

when u is the permeability.

CORRECTION FOR FORMS

In the foregoing no account has been taken of the fifth item on page 726, viz., *Form of Ship*.

Usually the effect of this correction is small, but in exceptional cases it may be large. It also generally increases the lengths of the flooding ordinates given by the Bulkhead Committee's diagrams (see Professor Welch, Trans. I.N.A., 1915, Vol. LVII., p. 14), and therefore its omission would be an error on the safe side.

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Table II.—Comparison of Floodable Length to Board of Trade and to Estimated Actual Permeability Taking Freeboard Ratio into Account.

Ship.	Voyage.	Draft. Leaving.	Draft. Summer.	Freeboard Ratio = Freeboard / Draft. Leaving.	Freeboard Ratio = Freeboard / Draft. Summer.	Nature of Cargo.	Permeability, percent. Actual Forward.	Actual Aft.	To Board of Trade. Forward.	To Board of Trade. Aft.	Floodable Length Error due to Freeboard Ratio and Permeability. Forward, Measured at 80% L from Aft End.	Floodable Length Error due to Freeboard Ratio and Permeability. Aft. Measured at 20% L from Aft End.	Permeability by Proposed Formula $U = 63 + \left\{32\frac{h}{H}\right\} + C$. Forward.	Permeability by Proposed Formula $U = 63 + \left\{32\frac{h}{H}\right\} + C$. Aft.	Percentage Error Proposed Formula and Board of Trade Method. Forward.	Percentage Error Proposed Formula and Board of Trade Method. Aft
		Ft. In.	Ft. In.													
Ship "A"	5 home	28 6	31 3	0.405	0.282	Mutton, Wheat, Wool, Skins	55.2	60.3	65.2	66.5	27.3	47.2	65.5	65.0	+0.5	—2.3
Ship "B"	home	24 0½	27 3	0.45	0.282	Tobacco, Rubber, Copra, Sago	67.8	66.1	64.2	64.1	26.6	36.1	63.0	64.0	—1.9	Nil
Ship "B"	6 home	26 1½	27 3	0.337	0.282	Copra, Hemp, Tea, Rubber, Nuts	60.9	56.5	64.2	64.1	18.0	27.3	63.0	64.0	—1.9	Nil
Ship "B"	7 home	26 1½	27 3	0.337	0.282	Copra, Hemp, Tea, Rubber, Nuts	65.5	61.1	64.2	64.1	10.0	17.85	63.0	64.0	—1.9	Nil
Ship "C"	1 home	26 6	28 2	0.331	0.253	Tobacco, Hemp, Rubber, Copra, Sessamun Seeds	60.0	57.7	64.1	64.0	24.9	28.8	63.0	64.0	—1.75	Nil
Ship "C"	2 home	25 4¾	28 2	0.391	0.253	Tobacco, Rubber, Hides, Tea, Nuts, Sessamun Seeds	63.5	63.3	64.1	64.0	29.5	29.5	63.0	64.0	—1.75	Nil
Ship "C"	3 home	25 9	28 2	0.371	0.253	Tobacco, Hemp, Hides, Tea, Nuts, Sessamun Seeds	59.9	62.5	64.1	64.0	32.9	26.9	63.0	64.0	—1.75	Nil
Ship "C"	10 home	26 1	28 2	0.354	0.253	Hemp, Copra, Hides	62.6	61.2	64.1	64.0	24.3	25.6	63.0	64.0	—1.75	Nil
Ship "D"	12 home	28 5½	30 9¼	0.495	0.382	Peas, Rice, Hemp, Sago, Copra	59.0	61.3	63.3	65.2	23.9	25.6	63.0	64.0	—1.75	Nil
Ship "E"	21 home	26 4	30 9¼	0.615	0.382	Hemp, Flour, Rubber, Tea	56.6	53.7	63.3	65.2	46.4	68.5	63.0	65.6	—0.5	+0.6
Ship "E"	37 home	23 0½	25 3	0.387	0.265	Tobacco, Sessamun Seeds, Nuts	65.3	64.5	63.3	63.7	19.7	23.7	63.0	65.6	—0.5	+0.6
	47 home	22 5	25 3	0.425	0.265	Copra, Rubber, Gambier	62.5	62.5	63.3	63.7	32.0	35.5	63.0	64.0	—0.5	+0.5
Ship "F"*	26 home	Indian Summer 27 2½	26 8½	0.298	0.322	Rice	58.2	57.7	63.2	63.2	5.4	2.6	63.0	64.0	—0.3	+1.2
Ship "F"	27 home	25 8½	26 8½	0.373	0.322	Rice, Copra, Maize, Beans	58.6	55.8	63.2	63.2	22.2	25.5	63.0	64.0	—0.3	+1.2
Ship "G"	6 home	24 1½	32 1¼	0.763	0.324	Hemp and Lumber (Passengers in 'tween decks)	64.5	64.7	69.6	71.8	65.0	82.5	69.1	71.25	—0.7	—0.8
Ship "G"	7 home	27 1	32 1¼	0.57	0.324	Salmon, Hemp, Lumber	59.2	59.8	63.7	64.5	44.0	53.0	63.3	65.6	—1.1	+1.7
Ship "H"	10 home	25 5	27 3	0.374	0.282	Hemp, Tapioca	59.0	57.3	64.2	64.1	28.9	36.5	63.3	64.0	—1.9	Nil
Average							61.1	60.3	64.2	64.7	28.3	31.9	63.5	64.8	—1.09	+0.155.

In all of the above cases the whole of the cargo space was occupied, except in the case of Ship *G*, Voyage 6, when passengers were carried in 'tween decks. *This vessel has no sheer.

The Bulkhead Committee assigned a permeability of 60 percent to all cargo spaces in a ship. It is obvious that this can only be an average figure, for the permeability of the holds of a vessel laden with iron ore would be considerably higher than 60 percent, while, on the other hand, the permeability of the holds of a vessel laden with a very light substance (hemp, for example) would be much less than 60 percent. In addition, it should be noted that the holds of the latter vessel would probably be full before the vessel was down to her maximum assigned draft, while in the former vessel there would be space in the holds for utilizing considerably more than this maximum draft if it were permitted. Thus an assumption of 60 percent for the permeability of all cargo holds might not only involve errors due to the different natures of cargoes, but there might also be errors due to variation in freeboard ratio, especially on the homeward voyages. This question has been exhaustively examined by Mr. G. W. Barr, of Messrs. Alfred Holt & Company, by whose courtesy the results shown in Table II are given.

The freeboards and permeabilities shown in this table are worked out for actual voyages, and the permeabilities of most of the different kinds of cargoes were determined experimentally.

It is seen that although the average of the actual permeabilities is not very different from that laid down by the Bulkhead Committee, yet the average errors in floodable lengths due to the variations in the freeboard ratios in actual practice are as much as 30 percent. These errors, it will be noted, are in the direction of making the ship safer.

It therefore appears that it is possible that the errors involved in assuming a fixed permeability for all cargoes, irrespective of their densities, might be much greater than those involved if the *Correction of Form* is omitted.

While it must be recognized that permeability of 60 percent appears to be a reasonable mean value for cargo spaces, it does not, in view of the foregoing, appear to be unreasonable to omit the *Correction for Form* altogether, especially when it is remembered that this variable is the most difficult of all to take account of, and that its omission would be an error on the safe side.

Calculation of Permeability

Under the present Board of Trade regulations it is necessary to ascertain the volumes of the various compartments in order to obtain the permeability. In the early stages of the design this information is not always easy to obtain, and the work would be simplified if the permeabilities could be based on figures which are readily available.

It has been found that the following formula, embodying only figures obtainable from the middle-line section, gives the permeabilities very closely:

$$\text{Permeability} = 63 + 32\frac{h}{H} + C,$$

where h is the mean depth below the bulkhead deck of the 95 percent spaces as defined in the present Board of Trade Regulations

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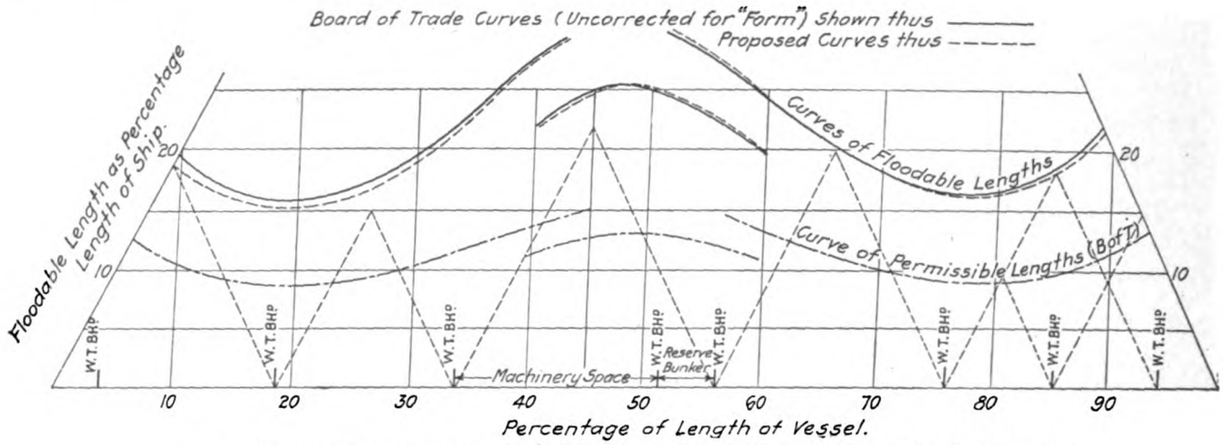
Board of Trade Curves (Uncorrected for "Form") shown thus
Proposed Curves thus
Floodable Length as Percentage Length of Ship.
Curves of Floodable Lengths
Curve of Permissible Lengths (B of f)
W.T.B.H.P.
Reserve Bunker
Machinery Space
Percentage of Length of Vessel.

Fig. 5.—Typical Curves of Floodable Length by the Board of Trade Rules and by the Proposed Methods for a Vessel 560 Feet by 68 Feet by 43 Feet

(exclusive of double bottom, peaks and tunnels), reduced in proportion which the mean length of such spaces bears to the length of the vessel measured between the forward machinery space bulkhead and the collision bulkhead, or between the aft machinery space bulkhead and the after peak bulkhead. The mean depth is to be measured from top of deck to top of deck at centerline.

H is the depth of the vessel from the top of keel to the margin line midway between the end of the machinery space and the forward or after end of the vessel.

C is zero for the forward end, 1 for the after end in single-screw vessels, and 2 for the after end in twin-screw vessels.

The permeability of machinery spaces in taken to be 80 percent for steamships and 85 percent for ships fitted with internal combustion engines.

This formula has been applied to the vessels given in Table II, and the results are included in that table.

It will be observed that the formula gives results which are on the average within 0.5 percent of those obtained by the Board of Trade method. It is evident, therefore, that no appreciable error will be involved if this formula is used for obtaining the permeability.

By means of the equation at the bottom of page 729, Table I, and the above equation for permeability, the flooding curve for any vessel can be obtained in about half an hour.

This method of obtaining flooding curves has been applied to a large range of ships, and it is found that the lengths of flooding ordinates obtained by this method are, on the average, within 2 or 3 percent of the floodable lengths obtained by the Bulkhead Committee's curves (but uncorrected for *form*).

A typical example showing a comparison of curves obtained by these two methods is shown in Fig. 5, and a typical example showing the small amount of labor in the calculation is shown in Appendix I.

Draft Penalty for a Long Hold

It should be noted that in obtaining values from Table II it is only necessary to read values of m to one decimal place, and values of a to three decimal places.

For instance, suppose in the example given in Appendix I the value of m at 15 percent station was 52.7 instead of 52.6, then the value of the flooding ordinate would be 15.87 instead of 15.84. Similarly, if the value of a at the same station was 0.042 instead of 0.041, then the flooding ordinate would be 15.90 instead of 15.84. The differences in both of these cases are much too small to affect the results in actual practice.

It will be observed that this method of obtaining the flooding curves is not only simple of application and involves little labor, but also enables the draft penalty for a long hold to be obtained.

Suppose in the example given in Appendix I that a hold 20 percent of the length of the vessel is required, with its center of length at 70 percent station.

The corresponding length of hold, if the permeability was 80 percent, would be:

$$20 \times \frac{63}{80} = 15.75 \text{ percent (permeability forward} = 63 \text{ percent)},$$

$$15.75 = m\,(a + f) = 56.7\,(0.050 + f),$$

$$f = 0.0228,$$

and

$$f = \frac{\text{freeboard}}{\text{depth}} = \frac{\text{freeboard}}{35},$$

$$\text{freeboard} = 7.98 \text{ feet},$$

$$\text{draft} = 35 - 7.98 = 27.02 \text{ feet}.$$

Reduction in draft = 28.0 — 27.02 = 0.98 feet, i. e., draft penalty = 0.98 feet = 12 inches (say).

The same method is applied for obtaining the correct permissible draft for a given spacing of bulkheads, if the first approximation should not be correct.

It has been shown that the results obtained by this method of calculation agree quite closely enough for all practical purposes with those given by the Board of Trade method, and in view of the extreme simplicity of application and the enormous saving in time and labor which the method affords, it is considered that it could be very profitably substituted for the present laborious and intricate method of calculation.

On examining Table I it will be seen that for a given station the difference between the values of m for the highest and lowest assumed sheer ratios is fairly constant for all block coefficients, and similarly for values of a. It therefore appears that Table I might be further simplified by giving values of m and a for one sheer ratio only instead of two, and giving for each station a correction factor which would have to be applied if the sheer ratio differed from that for which the table was drawn up.

Tables III and IV are drawn up on this basis, the values of m and a being correct for sheer ratios midway between the maximum and minimum sheer ratios of Table I, i. e., the values of m and a in Tables III and IV are correct for sheer ratios of 0.115 aft and 0.23 forward, and the necessary correction for every 0.01 alteration in the sheer ratio is given for each station.

These sheer corrections are correct for a block coefficient of 0.70, and in cases where the difference between the values of m (and a) for the two sheer ratios given in

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Table III.—Values of m.

Block Coefficient	Sheer Ratio (S/D) = 0.115. Station.						Sheer Ratio (S/D) = 0.23. Station.				
	A.T.	15	20	30	40	45	50	60	70	80	85	F.T.
0.60	40.60	56.66	56.43	65.30	94.18	104.70	97.75	70.65	53.43	52.67	59.33	38.50
0.61	40.40	56.20	55.95	64.83	93.70	104.70	98.30	71.25	53.60	52.29	58.83	38.46
0.62	40.20	55.75	55.48	64.39	93.25	104.70	98.83	71.81	53.72	51.90	58.32	38.42
0.63	40.00	55.32	55.01	63.98	92.82	104.70	99.32	72.33	53.82	51.56	57.80	38.38
0.64	39.80	54.90	54.56	63.60	92.40	104.70	99.80	72.81	53.90	51.21	57.27	38.33
0.65	39.65	54.50	54.14	63.25	92.00	104.70	100.25	73.24	53.96	50.88	56.73	38.26
0.66	39.50	54.11	53.74	62.93	91.60	104.70	100.68	73.61	54.03	50.56	56.20	38.18
0.67	39.36	53.73	53.35	62.65	91.21	104.70	101.09	73.93	54.11	50.25	55.70	38.09
0.68	39.23	53.36	52.98	62.40	90.84	104.70	101.48	74.23	54.20	49.95	55.20	38.00
0.69	39.12	53.00	52.61	62.18	90.49	104.70	101.85	74.53	54.30	49.65	54.70	37.90
0.70	39.03	52.65	52.25	61.99	90.16	104.70	102.24	74.85	54.40	49.37	54.21	37.80
0.71	38.96	52.30	51.90	61.83	89.86	104.70	102.65	75.21	54.53	49.12	53.73	37.70
0.72	38.92	51.96	51.57	61.70	89.60	104.70	103.08	75.62	54.70	48.88	53.27	37.60
0.73	38.90	51.62	51.25	61.60	89.37	104.79	103.55	76.11	54.91	48.65	52.81	37.51
0.74	38.90	51.26	50.94	61.53	89.17	104.90	104.06	76.70	55.18	48.44	52.35	37.43
0.75	38.90	50.88	50.63	61.50	88.01	105.03	104.62	77.39	55.52	48.24	51.90	37.36
0.76	38.90	50.50	50.33	61.50	88.91	105.20	105.25	78.18	55.93	48.07	51.47	37.30
0.77	38.90	50.10	50.03	61.50	88.85	105.40	105.95	79.09	56.41	47.92	51.05	37.28
0.78	38.90	49.69	49.75	61.50	88.82	105.64	106.70	80.14	56.96	47.80	50.65	37.28
0.79	38.90	49.26	49.47	61.50	88.82	105.92	107.49	81.31	57.59	47.70	50.27	37.28
0.80	38.90	48.80	49.20	61.50	88.82	106.23	108.30	82.60	58.30	47.60	49.90	37.28
Correction for 0.01 alteration in sheer ratio*.....	0.271	0.344	0.397	0.357	0.557	0.157	0.0585	0.387	0.314	0.450	0.4375	0.180

* Correction to be { added / subtracted } according as sheer ratio is { greater / less } than sheer ratio of table.

Table IV.—Values of a.

Block Coefficient	Sheer Ratio (S/D) = 0.115. Station.						Sheer Ratio (S/D) = 0.23. Station.				
	A.T.	15	20	30	40	45	50	60	70	80	85	F.T.
0.60	0.2625	0.0610	0.0315	0.0110	—0.0150	—0.0210	—0.0170	0.0085	0.0412	0.0790	0.1035	0.3788
0.61	0.2604	0.0590	0.0310	0.0125	—0.0130	—0.0195	—0.0160	0.0088	0.0398	0.0769	0.1010	0.3722
0.62	0.2580	0.0569	0.0305	0.0138	—0.0110	—0.0180	—0.0146	0.0092	0.0388	0.0749	0.0985	0.3665
0.63	0.2553	0.0547	0.0300	0.0150	—0.0090	—0.0165	—0.0132	0.0100	0.0380	0.0730	0.0960	0.3610
0.64	0.2523	0.0525	0.0294	0.0162	—0.0069	—0.0150	—0.0118	0.0110	0.0375	0.0712	0.0935	0.3555
0.65	0.2490	0.0501	0.0288	0.0174	—0.0048	—0.0135	—0.0104	0.0122	0.0375	0.0695	0.0910	0.3505
0.66	0.2454	0.0476	0.0281	0.0186	—0.0027	—0.0120	—0.0090	0.0135	0.0378	0.0679	0.0886	0.3455
0.67	0.2414	0.0449	0.0273	0.0197	—0.0006	—0.0105	—0.0075	0.0150	0.0383	0.0664	0.0862	0.3407
0.68	0.2370	0.0421	0.0265	0.0208	+0.0015	—0.0091	—0.0060	0.0167	0.0390	0.0651	0.0840	0.3360
0.69	0.2322	0.0393	0.0257	0.0218	0.0035	—0.0077	—0.0045	0.0185	0.0400	0.0640	0.0820	0.3312
0.70	0.2270	0.0367	0.0250	0.0228	0.0055	—0.0063	—0.0030	0.0203	0.0410	0.0630	0.0799	0.3263
0.71	0.2216	0.0342	0.0245	0.0238	0.0075	—0.0049	—0.0015	0.0222	0.0420	0.0620	0.0777	0.3214
0.72	0.2160	0.0320	0.0242	0.0248	0.0095	—0.0035	0.0000	0.0240	0.0430	0.0612	0.0755	0.3164
0.73	0.2103	0.0301	0.0242	0.0258	0.0115	—0.0022	+0.0013	0.0256	0.0445	0.0605	0.0733	0.3110
0.74	0.2044	0.0286	0.0242	0.0270	0.0135	—0.0009	0.0026	0.0270	0.0460	0.0600	0.0701	0.3052
0.75	0.1982	0.0275	0.0245	0.0284	0.0155	+0.0004	0.0038	0.0280	0.0475	0.0595	0.0689	0.2992
0.76	0.1917	0.0266	0.0252	0.0300	0.0173	0.0017	0.0050	0.0285	0.0490	0.0592	0.0666	0.2930
0.77	0.1850	0.0266	0.0263	0.0318	0.0191	0.0031	0.0060	0.0290	0.0507	0.0592	0.0643	0.2865
0.78	0.1782	0.0270	0.0279	0.0336	0.0208	0.0044	0.0068	0.0290	0.0525	0.0595	0.0620	0.2790
0.79	0.1712	0.0275	0.0298	0.0355	0.0223	0.0057	0.0074	0.0290	0.0540	0.0598	0.0595	0.2710
0.80	0.1640	0.0280	0.0320	0.0375	0.0238	0.0070	0.0080	0.0290	0.0555	0.0602	0.0570	0.2625
Correction for 0.01 alteration in sheer ratio*.....	0.0024	0.0040	0.0036	0.0034	0.0007	0.0002	0.0001	0.0002	0.0009	0.0005	0.0010	0.0010

* Correction to be { added / subtracted } according as sheer ratio is { greater / less } than sheer ratio of table.

Table I are constant for all block coefficients; the sheer corrections of Tables III and IV will be correct for all block coefficients, and in those cases Tables III and IV would give exactly the same results as Table I. In most cases, however, the above-mentioned differences are not constant for all block coefficients; but it will be noted that when these differences for values of *m* increase with increase of block coefficient, the corresponding differences for values of *a* decrease with increase of block coefficient, and vice versa.

Thus, on examining the values of *m* and *a* obtained from Tables III and IV, it is seen that when the value of *m* obtained by Table III is less than that obtained from Table I the value of *a* by Table IV is greater than that obtained from Table I, and vice versa. Consequently, the flooding ordinates given by these two methods are in very close agreement.

For example, for a block coefficient of 0.62, the values of *m* and *a* at 80 percent station for sheer ratios of 0.30 are 55.4 and 0.077 respectively by Table I, and 55.05 and

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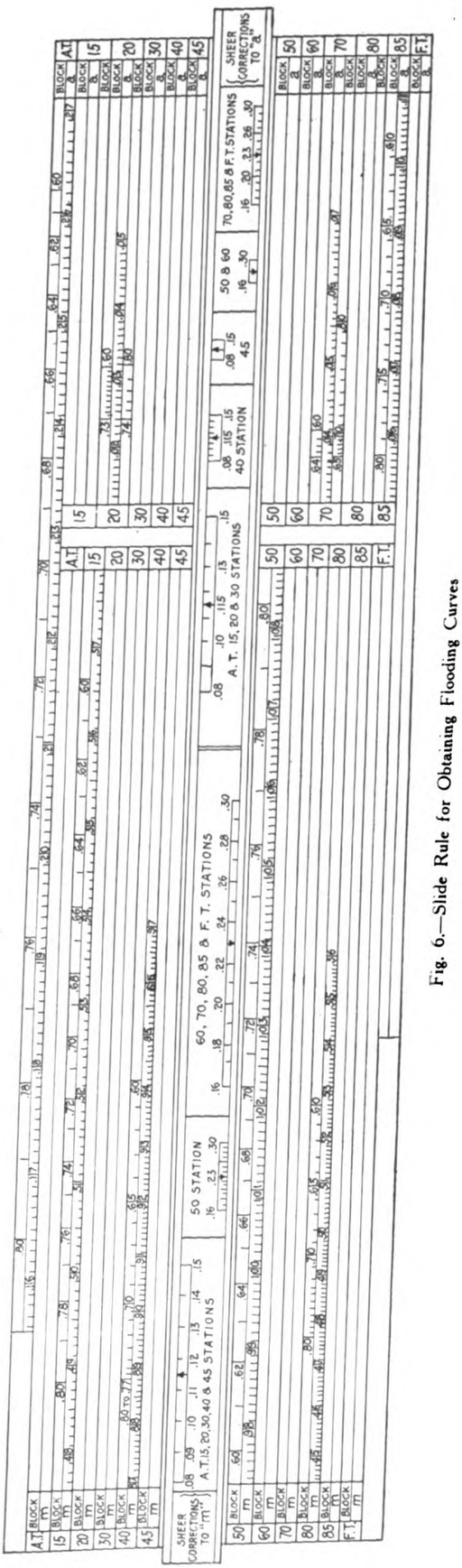

Fig. 6.—Slide Rule for Obtaining Flooding Curves

0.078 respectively as given by Tables III and IV.

Assuming a freeboard ratio of, say, 0.20, the former results give a flooding ordinate of (55.4 × 0.227) = 15.35, while the latter results give a flooding ordinate of (55.05 × 0.278) = 15.35.

It is thus seen that Tables III and IV give results which are in close agreement with those given by Table I.

SLIDE RULE FOR OBTAINING FLOODING CURVES

It appears from the nature of Tables III and IV that it should be possible to construct a slide rule embodying the results contained in the tables.

There are three variables to be considered, viz., block coefficient, sheer ratio, and m (or a).

There are several ways in which these variables can be plotted in the form of a slide rule, but the simplest has been found to be as shown in Fig. 6. Values of block coefficients m and a are arranged on the fixed portion of the scale, while corrections to m and a for variations in sheer ratio are arranged on the sliding portion.

It is found that by varying the scales for values of m and a at different stations, it is possible to make one scale of corrections for sheer ratio do for several stations, and thus the amount of data on the slide is reduced to a minimum.

On examining Table IV, it will be noted that at some of the stations the values of a do not increase or decrease continuously with increase of block coefficient (stations 15, 20, 70 and 80). Consequently, in these cases there will be two block coefficients for one value of a. This difficulty can be overcome in plotting by dividing the scale of block coefficients into two, at the point where the values of a stop descending and commence to ascend (or vice versa), one portion of the divided scale of block coefficients being arranged above the scale of a and the other portion below it (see Fig. 6).

By means of this slide rule it is now possible to obtain the ordinates of the flooding curve for a ship in less than ten minutes.

The line of the cursor is placed over the required block coefficient for any given station. If the sheer ratio is normal (i. e., 0.115 aft or 0.23 forward), the value of m (or a) can be read off from the scale of m (or a) immediately below the scale of block coefficients. If, however, the sheer ratio is not normal, the sliding scale is moved until the normal sheer ratio for the particular station is under the line of the cursor. The cursor is then moved until the line on it is over the required sheer ratio for the given station, and the value of m (or a) for the given station under the line of the cursor is read off.

Knowing, therefore, the block coefficient and the sheer ratio, the values of m and a can be obtained for each station in the ship from the slide rule, and by the method shown in Appendix I the ordinates of the flooding curve can be quickly found.

APPENDIX I

TYPICAL CALCULATION

A typical calculation for the floodable length curve is as follows:

s.s.....

$452 \times 56.0 \times 35.25$

Depth to margin line.....	= 35.0
Molded draft	= 28.0
Freeboard	7.0
Block coefficient	0.73
Freeboard ratio $= \frac{\text{freeboard}}{\text{depth}}$	0.20

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Sheer forward = 10.0 sheer ratio forward $\frac{\text{sheer}}{\text{depth}}$. 0.280

Sheer aft = 5.0 sheer ratio aft $\frac{\text{sheer}}{\text{depth}}$ 0.143

No passengers below bulkhead deck.

$\therefore u = 63$ forward, and 64 aft (per formula on page 729).

				Floodable Length — Machinery Space	Floodable Length — Ends
Station	m	a	$a+f$	$m(a+f)$	$\frac{80}{u}[m(a+f)]$
A.T....	39.7	0.218	0.418	16.58	20.75
15.....	52.6	0.041	0.241	12.67	15.84
20.....	52.4	0.034	0.234	12.24	15.30
30.....	62.5	0.037	0.237	14.81	18.51
40.....	90.9	0.014	0.214	19.45	24.30
45.....	105.2	0.002	0.198	20.84	26.08
50.....	108.9	0.002	0.202	21.00	26.65
60.....	78.4	0.026	0.226	17.72	22.50
70.....	56.7	0.050	0.250	14.18	18.00
80.....	51.1	0.064	0.264	13.49	17.13
85.....	55.3	0.078	0.278	15.36	19.50
F.T....	88.5	0.317	0.517	19.88	25.25

NOTE.—For the forward and after terminals, the ordinate of the flooding curve as given by the formula must be plotted on a vertical line situated at a distance from the particular terminal equal to one-half the floodable length given by the formula for a permeability of 80 percent.

Report of Education Committee of the Engineering Section of the National Safety Council*

BY W. D. KEEFER

ALMOST everyone who is familiar with the engineering courses offered in the average technical school and university in our country agrees that our student engineers are being taught technical subjects that fit them to solve problems where materials, machines and forces of nature are involved, but that practically nothing is taught them to assist in solving the problems involving men.

The importance of this phase of engineering education was recently made apparent by the result of an investigation conducted by the Carnegie Foundation for the advancement of teaching. Starting in the year 1915, Dr. Mann sent out questionnaires to leading engineers all over our country asking them to state their views concerning the elements that make for the professional success of the engineer. A statistical summary of over 6,000 returns revealed the following:

	Percent
Character	24
Judgment	19.5
Efficiency	16.5
Understanding of men	15
Knowledge of fundamentals	15
Technique	10

This being true, the colleges cannot limit themselves to the teaching of those subjects which make for perfection in professional knowledge and technique. They must also consider the development of judgment, understanding of men, efficiency and character.

Many persons interested in safety think that a presentation of the principles of accident prevention to student engineers will assist materially in developing a proper understanding of men, and at the same time make a valuable addition to the student's engineering knowledge. They base this statement on the fact that successful safety work is the result not only of the proper application of true engineering principles but also of the ability to understand and handle men. Without stopping to discuss this in greater detail, let us consider for a moment how the engineering section of the council can best assist our engineering colleges.

The National Safety Council has in the past two years been devoting some time and money to the consideration of this problem, and at our suggestion Mr. George F. Blessing, now of the Rockefeller Foundation and formerly the professor in charge of engineering at Swarthmore College, a member of our education committee of this section of the council has outlined some practical suggestions. These suggestions have been submitted to the other members of this committee, and it is my pleasure to report to you the concensus of the comments of the committee thereon.

(1) Safety education in engineering colleges should not be confined to preparing safety engineers. A greater effort should be made to impress all engineering students with the fact that safety is an integral part of efficiency. Then when these students begin their real work, of whatever kind, they will know that the full measure of efficiency cannot be obtained without safety receiving full consideration. They will also have the knowledge to direct this work. Safety should therefore be worked into all engineering courses where it is appropriate. Such courses as machine design, shop practice, industrial management and others are particularly suitable for the inclusion of safety material.

(2) Safety can best be presented to the engineering educator as well as to the engineering student, as a subject definitely related to engineering efficiency, rather than as a humanitarian subject of general interest to everybody.

(3) Opportunities should be provided for any engineering professors who wish to do so to take up summer work in the safety departments of some of the large companies.

(4) Encourage colleges to take out a $15-a-year membership in the National Safety Council, which membership will make available all the council's bulletins and other publications.

(5) Urge colleges to post safety bulletin boards in the engineering shops and keep them alive with the council's bulletins and other literature pertaining to Safety.

(6) Assist engineering colleges in establishing individual safety museums. The council could advise the colleges in this work and suggest the names of persons and companies who are willing to co-operate in supplying material for this purpose.

(7) Attempt to have the standard engineering handbooks introduce a safety section to include safety codes and principles that apply to the particular branches of engineering which the handbook covers.

(8) The time is not yet ripe for the preparation of a college textbook on safety.

* Read before the conference of the engineering section of the National Safety Conference, Chicago, June 24.

Standardization of Shafting

The American Engineering Standards Committee has invited the American Society of Mechanical Engineers to act as sponsor for the standardization of shafting. The society has already done a considerable amount of work on a set of standard diameters for transmission and machinery shafting. It is proposed that the work, which will be carried out by a sectional committee working under the rules of procedure of the American Engineering Standards Committee, shall be broadened to include the standardization of the method of determining what diameters of transmission shafting should be used for given loads, the dimensions of shafting keys and keyways, and the setting of dimensional tolerances.

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The Shipping Board Feels Its Way

BY WALDON FAWCETT

The temptation of the Shipping Board to await the forthcoming verdict of the country at large on legislative policies is the more readily understandable in the face of the expressed desire of the Board to work in sympathy and co-operation with the merchant marine committees of the United States Senate and House of Representatives. This spirit is exemplified in the handling of the question of American marine insurance. The Shipping Board is whole-heartedly behind the American marine insurance syndicates—the union of most of the existing American marine insurance interests—but is further pressing the issue on the theory that various legislative disabilities must be removed ere American marine insurance companies can be placed on an equality with foreign competitors. To accomplish this will require action by various State legislatures as well as by the national legislature.

PROBABLY no man in the shipping and shipbuilding field, however impatient for the creation of a permanent American merchant marine worthy of the nation, expected that the announcement of a detailed program to this end would follow close upon the passage of the Merchant Marine Act. If there be any such, assuredly he has been doomed to disappointment, for the evolution of general policies is proceeding with the deliberation that is well nigh imperative in an undertaking of such magnitude. Formulation of policies and the inauguration of new activities have, by no means, waited upon the long deferred appointments to the Shipping Board, but two fundamental influences have counseled what might appear to an outsider conservatism and deliberation in the application of the new law designed to provide American instrumentalities for our water-borne commerce.

One restraining influence has been supplied by the circumstance that the new Merchant Marine Act is, as our readers doubtless appreciate, a voluminous and complex statute requiring careful study on the part of administrators in order that its provisions may be properly interpreted. At the headquarters of the Shipping Board the new law has been taken up section by section and carefully analyzed. The ambition has been to grasp, on behalf of the executives, not only the letter but likewise the spirit of the set of instructions furnished by Congress. This scrutiny, paragraph by paragraph, has naturally consumed considerable time. Indeed, it is only in the late summer of 1920 that we find the legal advisers of the Shipping Board ready to advise their principals as to how they may and should proceed under the authorization.

The Shipping Board Marking Time

Pending the determination of the all but judicial construction to be placed upon the diverse stipulations of the Merchant Marine Act, the Shipping Board has been compelled obviously to mark time. This influence, then, in behalf of deliberation has been an outside one, so to speak. It has been a necessity imposed upon the Board whatever its will to proceed. The other fundamental influence above referred to has been like in effect but of very different genesis. On this count we find the Shipping Board showing deliberation of its own volition.

To quote the words of a prominent executive, the Shipping Board is "feeling its way" not because it is in any doubt as to its objective, or is even hesitant as to the means that may best be employed to reach that objective, but simply by reason of uncertainty as to future external conditions that must inevitably affect the shipping and shipbuilding industries. There is not only a domestic transportation situation but a world condition to be taken into account in formulating a merchant marine program. The state of the money market, too, is calculated to have a bearing upon the employment of the national merchant fleet and the expansion of that fleet. And, finally—and most potently—the merchant marine program waits upon the outcome of the national elections in November, not so much because of the political element involved, strictly speaking, as by reason of the effect that election will have upon national policies and business conditions.

General Policies Being Evolved

In a nutshell, it may be put that the Shipping Board is working consistently and persistently to the evolution of general policies, but for the time being the disposition is to take decisive action only upon the propositions that require immediate attention to avoid loss or inconvenience. To the same end a sufficient-unto-the-day policy has been adopted. No issues are raised, but instead attention is confined to the issues that are thrust forward.

That the Shipping Board administration is not lacking in courage, however, nor in willingness to grapple with a situation that is menacing in any respect is attested by what has been done with wooden ships built during the war. In some respects it would have been the simple solution of a perplexing problem to have continued in operation the entire fleet of upward of three hundred wooden ships, even though it required a lavish use of public funds. The Shipping Board has not hesitated, however, as between the considerations of depreciation and operating expense. In consequence, we find more than one hundred of the wooden ships lying at anchor in the James River while scores of others are at various ports on the Atlantic Coast. The significant fact that not a bid was received when twenty-one of these vessels were offered for sale several months ago renders disquieting the whole problem of the wooden ships, but whether the only escape from the dilemna lies in the conversion of the wooden ships into barges for coastwise service or in some other equally drastic remedy the Shipping Board will not be disposed to temporize once its duty is clear.

Something of the same limitations that have operated to cause the Shipping Board to make haste slowly with its general policies have influenced the arrangements for the sale of surplus material, aside, of course, from the vessels. In the main, the sale of the surplus material has waited upon the completion of the surveys of material on hand. With the waning of summer the Shipping Board came into possession of preliminary surveys that will be used as a basis for a selling campaign, but the tentative surveys are subject to revision, with corresponding amendment of the sales programme. For the reassurance of the construction and supply branches of the industry it may be said that the Shipping Board officials promise, in plan-

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ning the sales of surplus material, to be duly mindful of their moral obligation not to disturb the normal, rational market for marine equipment. In this respect the Shipping Board will have the benefit of the experience of the United States Army organization in disposing of its surplus property.

To Break Up Monopoly of Atlantic Seaports

In the expressions thus far made by Admiral Benson in hint of the governing policies that will actuate the Shipping Board, there is but one note that may savor of the radical in the estimation of some shipping interests. The innovation in question is that which promises "to break up the monopoly heretofore held by a few Atlantic seaports." It will be understood that the head of the Shipping Board has reference to shipping, not to shipbuilding, and he frankly ascribes whatever concentration exists to inadequate loading and unloading facilities at the neglected ports and to indifference on the part of the communities rather than to any ulterior motives on the part of the shipping interests that have "followed the crowd." Wherever lies the blame, the Shipping Board has voiced a determination to "spread the shipping." By so doing, it is argued, the development of the merchant marine will be stimulated and there will be afforded a measure of relief for the congestion of freight at railroad terminals, which "jam" of export shipments constitutes, just now, one of the gravest problems confronting business America.

That the policy which the Shipping Board is instituting in this respect bespeaks vision and imagination is attested by the appeal of Admiral Benson to American manufacturers to so route exports and imports that the facilities of the rail and water carriers of the United States can be used to the best advantage. It is the ambition of the Shipping Board to bring about a proper balance between rail and water carriers. The subject is intimately related, indeed, to the reform above mentioned which aims at the decentralization of American shipping. The theory of the Shipping Board is that there are certain zones of economic movement of exports originating upon rail lines, and if these zones can be made properly tributary to the logical outlets or ports of dispatch there will be created a form of harmonious team-play that will be the best augury of a noteworthy merchant marine.

Shipping Controlled by the Government

With the Shipping Board thus nominating policies that go to the very foundation of the American transportation structure, it becomes of interest what proportion of the shipping in commission is subject to the will of the Board. With this thought in mind, the latest figures are illuminating. The compilation of maritime resources, as of date of July 1, 1920, shows the Shipping Board in control of more than 50 percent of the tonnage and with almost the entire fleet, aside from a number of wooden vessels, in active service. The Shipping Board's holdings, on the date indicated, comprised 1,502 vessels of 6,238,948 gross tons or 9,358,421 deadweight tons. This total is to set over, for purposes of comparison, against the full strength of the sea-going merchant marine of the United States, which totals 3,404 vessels of 11,278,741 gross tons or 16,918,212 deadweight tons. The dominance of the Shipping Board on the side of the cargo carrying is indicated by the fact that of the 1,502 vessels owned and controlled by the Board on the date mentioned, 1,394 were cargo vessels, 27 were cargo and passenger vessels, 63 were tankers, 15 refrigerators and three transports.

One obligation to find itself on policy that will brook no extended delay, whatever might have been the desire of the Shipping Board, is that which involves the application of Section 28. This is the section of the Jones Merchant Marine Act of 1920 which is avowedly designed to prevent foreign shipping interests from discriminating against American vessels. It is claimed that foreign shipping interests, particularly those operating on the Pacific, have conducted an organized propaganda designed to discredit this feature of the merchant marine program and to arouse opposition, within the United States as well as outside, to Section 28. Thus challenged, the Shipping Board has declared that it will follow a policy for which, indeed, the law allows it no alternative, viz., strict enforcement of the discriminatory mandate, provided there be available ample tonnage under the United States flag.

Section 28 of the Merchant Marine Act

The discussion of the use of the powers vested in the Shipping Board and the Interstate Commerce Commission under Section 28 in the event that an attempt should be made, say, to divert Pacific commerce to Vancouver, British Columbia, has "cleared the atmosphere" with respect to one phase of Shipping Board jurisdiction that has occasioned some misunderstanding despite the apparent clarity of the enabling act. Admiral Benson, chairman of the Board, has taken occasion in his talks with interests that have been alarmed by threats of foreign retaliation to point out that neither the Board nor the Interstate Commerce Commission has authority to enforce the provisions of Section 28 as affecting the business of a foreign port or a port in a possession or dependency of the United States unless ample tonnage is available. Going farther, the Shipping Board head has accepted the construction which represents the Merchant Marine Act as concerned primarily with the conservation and continuation of United States shipping in American trades. To that end, American ships engaged in trade between foreign countries are given no advantages. The preferentials created by the recent action of Congress apply only to American ships operating between the United States and overseas ports.

In connection with the situation which has been precipitated by alien resistance to the "double standard" set up under Section 28, considerable interest may naturally attach on the part of shipping men to the distribution of the Shipping Board's fleet. By way of definite alien opponents engaged in the commerce of the western ocean, the Shipping Board has stated that when it has occasion to enforce Section 28 it will be prepared to supply any deficiencies in American tonnage in operation from Pacific ports in order that there may be no restriction upon the movement of American commerce. With that responsibility and others of like kind in mind, there is bound to be interest in the strategy which the Board shows in the disposition of its fleet.

Distribution of the Shipping Board's Fleet

At the beginning of the fiscal or official year only 16 percent of the tonnage controlled by the Shipping Board was in the trans-Pacific trade as compared with 39 percent in the northern European trade, 10 percent in the southern European, 11 percent in the South American, and 9 percent in the West Indian and Caribbean. In the allocation of the steel vessels engaged in these services we find much the same proportionate balance of strength. To be specific, 615 of the steel vessels are operating from north Atlantic ports, 62 from south Atlantic ports, 184 from Gulf ports and 113 from Pacific ports.

The Shipping Board will be in the better position to turn, if need be, energetically to the development of a

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governmentally-sponsored merchant marine on the tran-Pacific routes now that it has well in hand its first labor of love in behalf of the extension of Yankee trade, viz., the provision of direct service between the United States and Latin-American ports. By recent inventory, the Shipping Board has in trade between this country and ports in Central and South America forty-one direct service lines employing 134 cargo vessels of 860,180 deadweight tons. Naturally, the bulk of the traffic is found, at least for the time being, on the trade lanes extending from United States Atlantic and Gulf ports to the east coast of South America. On these routes the Shipping Board has in operation 23 lines enlisting 94 vessels of 648,504 deadweight tons. From Atlantic and Gulf ports to the west coast of South America, 10 direct service lines are operating 28 vessels of 151,686 deadweight tons. From the Pacific Coast of the United States to the east coast of South America—an important innovation—the Shipping Board has inaugurated a line that is operating two vessels of 15,000 deadweight tons. And from the Pacific coast the Board is operating to the west coast of South America four direct lines engaging four vessels of 21,800 deadweight tons.

Whatever responsibilities or complications may result from the enforcement of Section 28—"the teeth" of the Merchant Marine Act, it has been characterized—are presumably postponed, however, until after the first of next year. This is the consequence of the action of the Shipping Board in certifying to the Interstate Commerce Commission the desirability of extending until January 1, 1921, the period of suspension of the provisions of Section 28. The Board came to the conclusion that the 90 days' suspension heretofore in force is not sufficient for proper inquiry into the subject and that it will be the first of the year ere it can make intelligent application of the provisions which prevent American railroads from making preferential rail rates for commodities moving in import or export except when moved in American ships. Postponement until the new year will, it may be appreciated, allow the Shipping Board to follow its impulse to hold back in so far as possible on the formulation of policies until after election and the reassembling of Congress and, incidentally, to co-ordinate its policies on all the most important questions before it. It will also give new members of the Board a voice in shaping its policies.

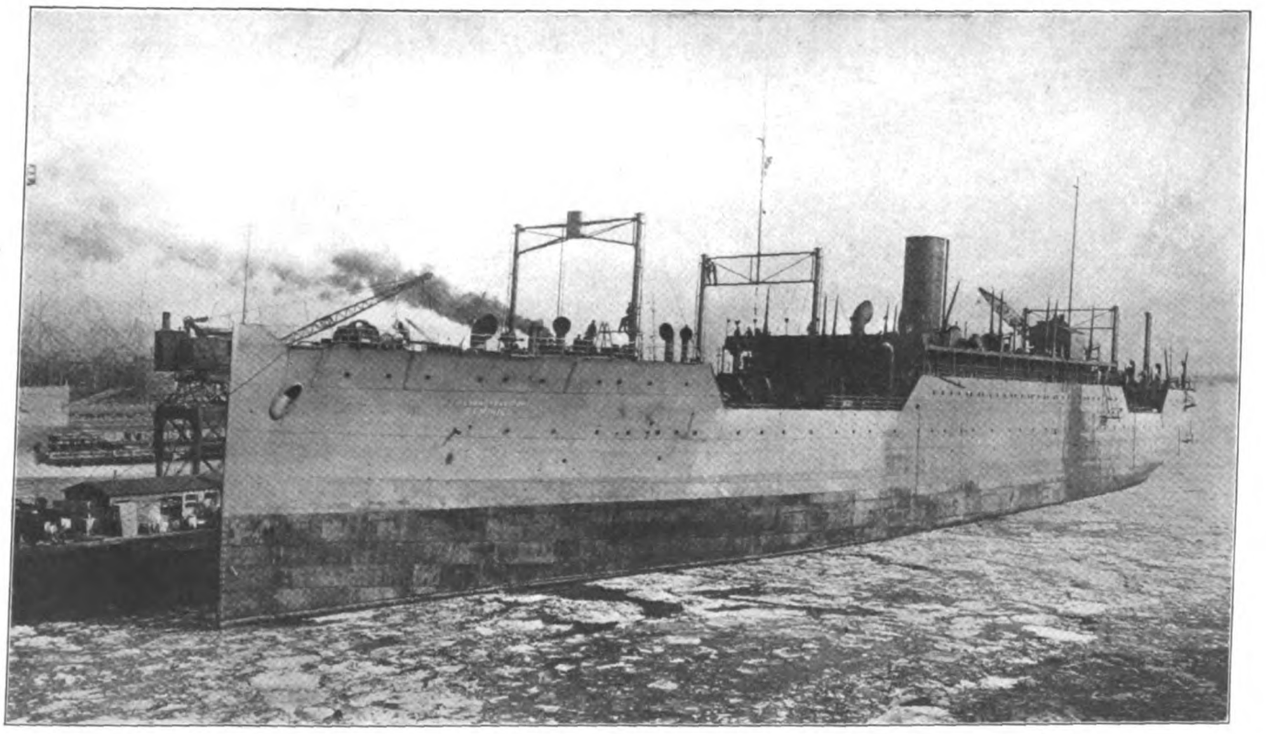
Troopships Completed at Hog Island

Description of 6,000-Horsepower, General Electric Geared Turbine Installations on Vessels to Be Used in Philippine Trade

THE first of the twelve troopships being built by the Government at the Hog Island yard recently made her trial trip, developing an average speed of 16.75 knots for four runs. These vessels, which are to be used between the United States and the Philippines, are all of one type. The main dimensions are as follows: Length between perpendiculars, 448 feet; beam, 58 feet; draft, loaded, 28 feet ¾ inch.

The vessels are equipped with 6,000-horsepower marine geared turbines, furnished by the General Electric Company of Schenectady, N. Y., being among the 122 vessels built at the Hog Island yard since its establishment, all of which have been equipped with General Electric marine geared turbines.

The propelling machinery, designed to give the ship a speed of 15 knots, consists of a cross-compound Curtis



U. S. S. *St. Mihiel*, Equipped With General Electric Geared Turbine of 6,000 Horsepower

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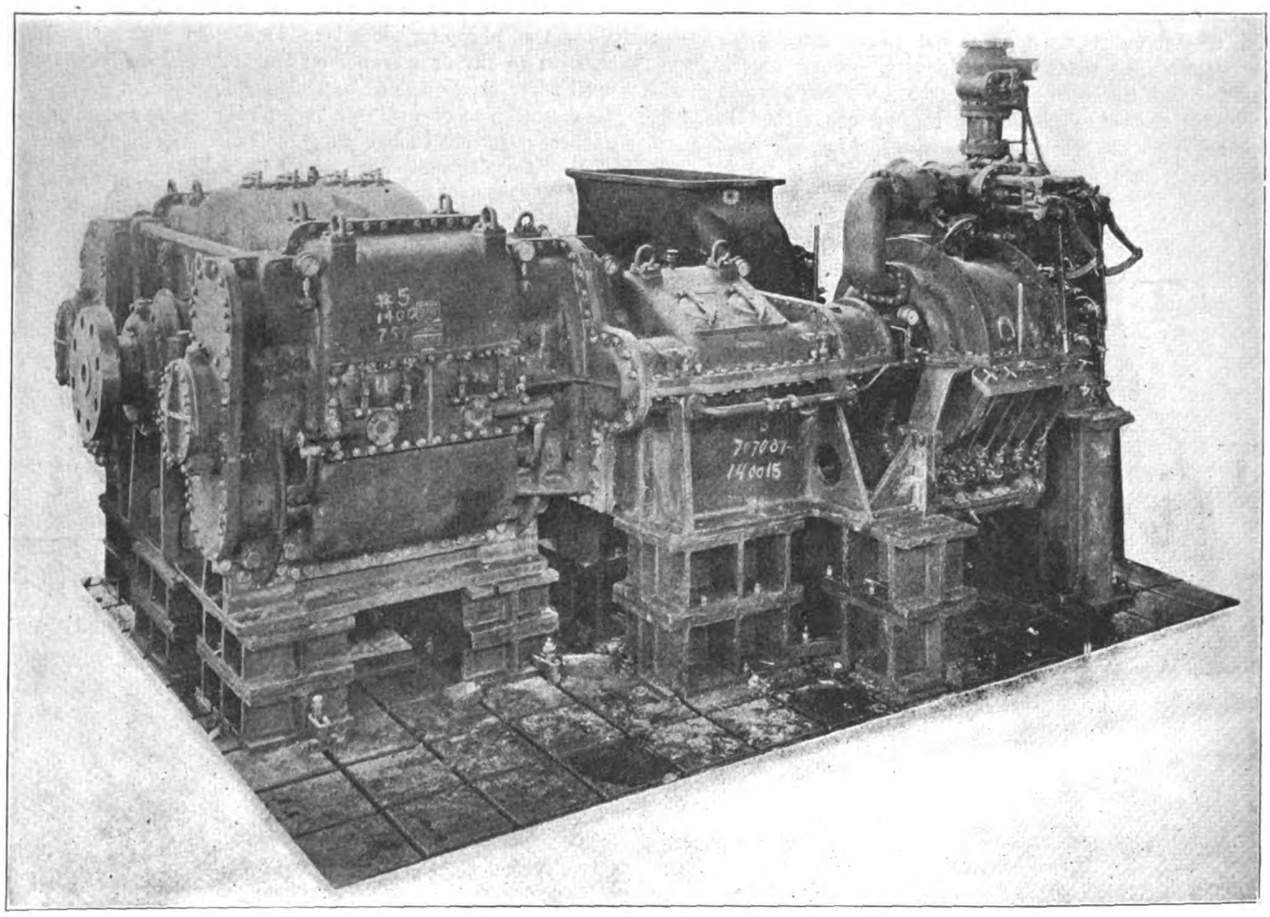
steam turbine, which is divided into a high pressure and low pressure section, and a set of double reduction, twin drive, one plane, speed reducing gears. The turbine delivers its contract full power at a speed of 3,836 revolutions per minute for the high pressure section and of 3,428 revolutions per minute for the low pressure section. The reduction of speed from that of the turbine to that of the propeller is accomplished in two steps. The total speed reduction from the turbine speed of 3,836 revolutions per minute and 3,428 revolutions per minute to the gear or propeller speed of 100 revolutions per minute gives a ratio of 38.36 to 1 and 34.28 to 1, respectively.

The direction of rotation of the turbine wheels for both the high pressure and the low pressure sections is clockwise, or right hand, when viewed from the after or gear end.

The direction of rotation of the low speed gear and propeller shaft is counter clockwise, or left hand, when viewed from the after end.



Starboard View of 6,000-Horsepower Geared Turbine Marine Unit, Looking Inboard

TURBINE

The turbine consists of two parts, a high pressure and a low pressure section, located on the starboard and port sides of the ship respectively. The sections can propel the ship independently of each other, in case of a breakdown of one section. They are arranged in separate casings, with the rotor of each connected to a separate pinion. Each section consists of three stages ahead and one stage astern, embodying an ahead and an astern element, which are both carried on one shaft in one casing. Full power is delivered at a steam pressure of 185 pounds, the steam being superheated 75 degrees F. and exhausting into a vacuum at 28.5 inches.

Each turbine section develops one-half of the full contract power for running ahead. The astern power developed is two-thirds of the full ahead torque.

The turbines follow closely the design of the 2,500-3,000 horsepower General Electric marine geared turbine which has given excellent service in cargo boats. Steam is admitted through the combined strainer and emergency valve into the ahead or astern steam bowl of the high-pressure section, passes through the stages of this section and is led through the cross-over connection to either the ahead or astern steam bowl of the low pressure section and exhausts into the condenser. In case of overspeeding of the unit, or in any other emergency case, the steam is shut off by an emergency valve connected to the emergency tripping device.

The balanced, horizontal spindle, maneuvering valve directs and controls the steam to the ahead and astern elements of the turbine, the hand levers being so interlocked that only one of the valves can be opened at a time. In addition there are installed two hand valves for further controlling the steam supply to the first stage nozzles of the high pressure section when less than full speed is desired. Leakage of steam to the astern element is prevented by a guarding valve.

The connection between the turbine shafts and the high speed pinions is established by pin couplings, allowing free axial movement of the gear elements.

An emergency governor is fitted to the forward end of each turbine shaft, and a tripping device is installed to

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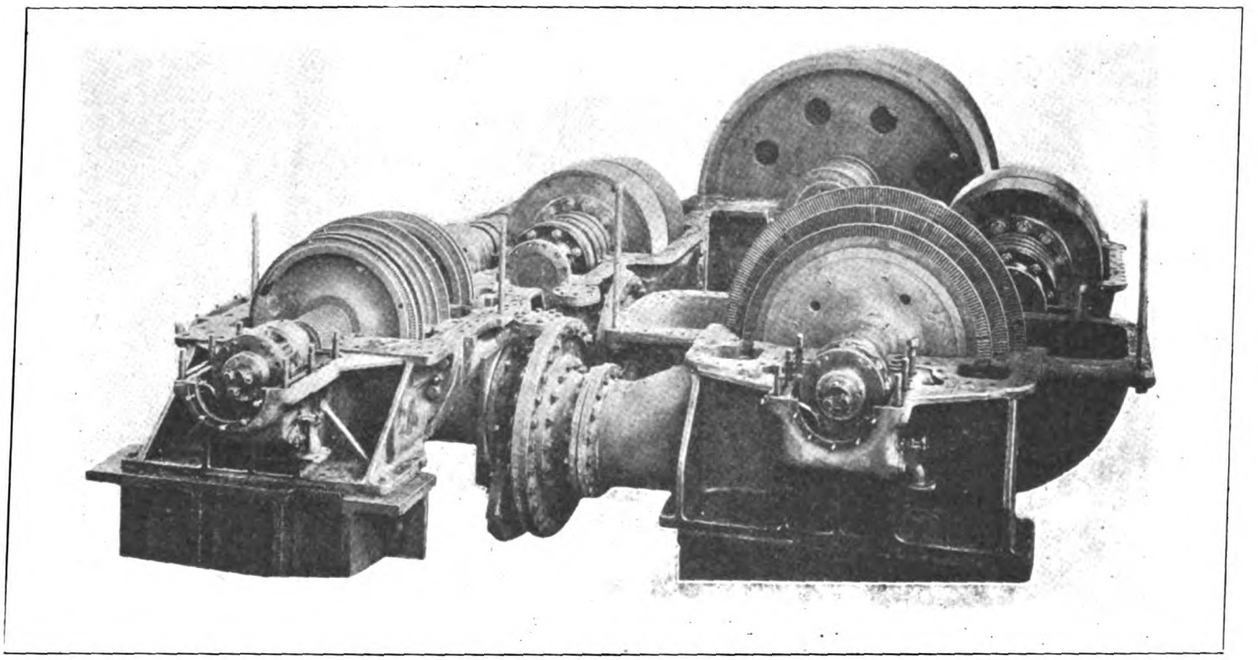
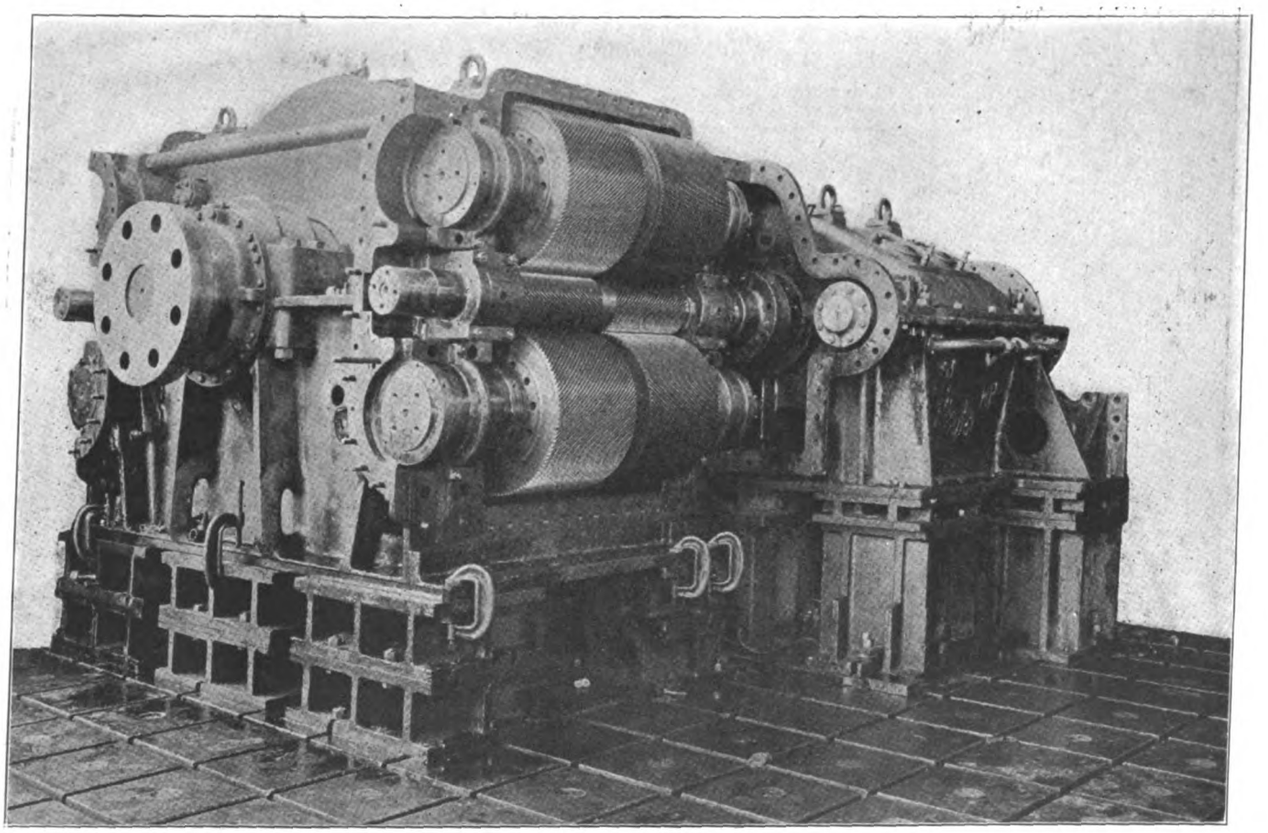


Upper Halves of Casings Removed on 6,000-Horsepower Marine Turbine Unit, Showing Rotors in Position

safeguard the unit by automatically shutting off the steam, if the machine should over speed, or the lubrication system should fail to function.

The cross-over connections between the two turbine sections are constructed to permit the engineer to make the steam supply connections so as to operate either section separately, in case of emergency.

The speed reducing gears are mounted directly abaft the turbine and are divided into two elements, a high speed element and a low speed element. The high speed reduction consists of two parts, in two separate casings, one of which is bolted to the low pressure, the other to the high pressure section of the turbine, while the low speed gears are contained in one casing, the frame being con-



6,000-Horsepower Marine Gear With Side of Main Gear Casing Removed, Showing Pinion Gear Idlers

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tinuous for the turbine and gears, making a complete unit.

The high speed reduction consists of a flexible high speed pinion and a flexible high speed gear. The high speed pinions consist of three parts—the flexible shaft, which is coupled to the turbine shaft, the quill pinion, and the coupling connecting the flexible shaft to the quill pinion.

High Speed Reduction

The high speed gear wheels are of the alquist flexible disk type and are built up from a number of disks which are mounted on, and firmly bolted to, the middle flange of the hub, dividing the gear into two halves. The disks are separated by a small clearance space at their peripheries and are capable of axial deflection, which insures an equal distribution of load over those parts of the teeth in mesh.

Low Speed Element

The low speed pinions have teeth machined on the peripheries and are connected to the high speed gears by solid flanged couplings.

The low speed gear wheel is a strongly ribbed casting, with the rim turned and grooved to receive the gear blanks. The wheel is pressed and keyed on the shaft.

Lubrication

The bearings of the turbine and the gears, the gears, the pin couplings, the thrust bearings, etc., are lubricated from the main oil circulating system of the ship.

Bulk Cargo Handling on the Atlantic Coast

Improved Machinery, First Developed on the Great Lakes, to Be Adapted for Handling Bulk Cargoes at Atlantic Ports

IN the past four years several factors have caused a stimulation of interest among shippers of heavy bulk materials in a cheaper and more rapid scheme of handling such commodities. The manufacturers of apparatus, especially the pioneers in this line, started a movement in this direction some twenty years ago and succeeded in getting a limited number of plants installed as early as 1902. The development of plants for handling large tonnage of coal and iron ore was the most obvious necessity, and it was naturally the first problem attacked on a large scale.

The necessity for such development centered around the Great Lakes region, and the pioneer installations were put in in this vicinity. The short season of navigation from the Minnesota, Wisconsin and Michigan ore fields to the blast furnaces of the lower lakes and the Pittsburgh district requires a movement of twelve months' supply of ore in about seven months. The coal supply of the states bordering on the iron ore region was largely taken from the lower lakes on the return trip of the ore boats. In order to perform this task with the minimum of equipment and operating costs per ton, it was plainly necessary

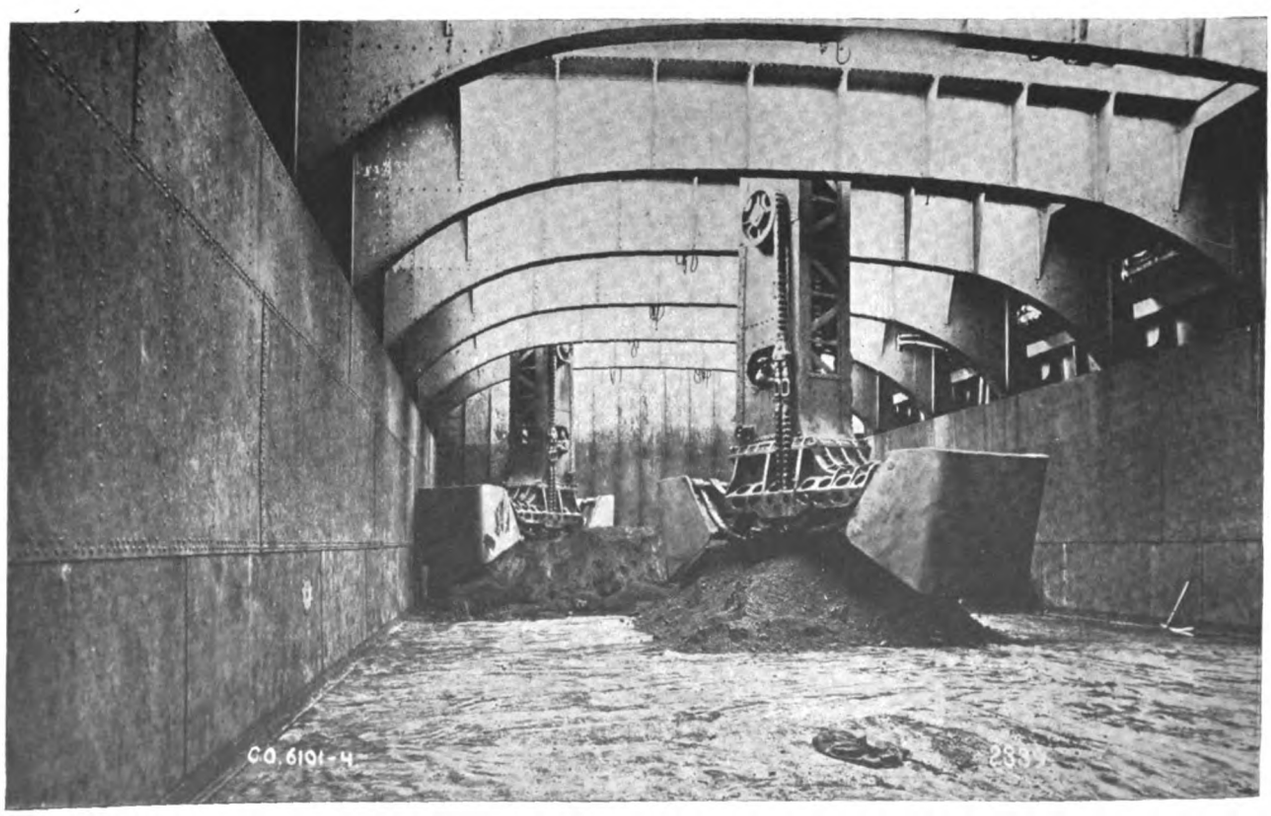

Fig. 1.—Unloader Leg and Bucket of a Wellman-Seaver-Morgan Unloader at Work in the Hold of a Modern Boat

The leg is so mounted in the walking beam that it can rotate in a circle, allowing the bucket to reach out in all directions. These machines have often unloaded 97 percent of a cargo without the help of shovelers. The position of the operator who controls the movements of the bucket is shown above. The distance from point to point of the bucket shell when open is 21 feet.

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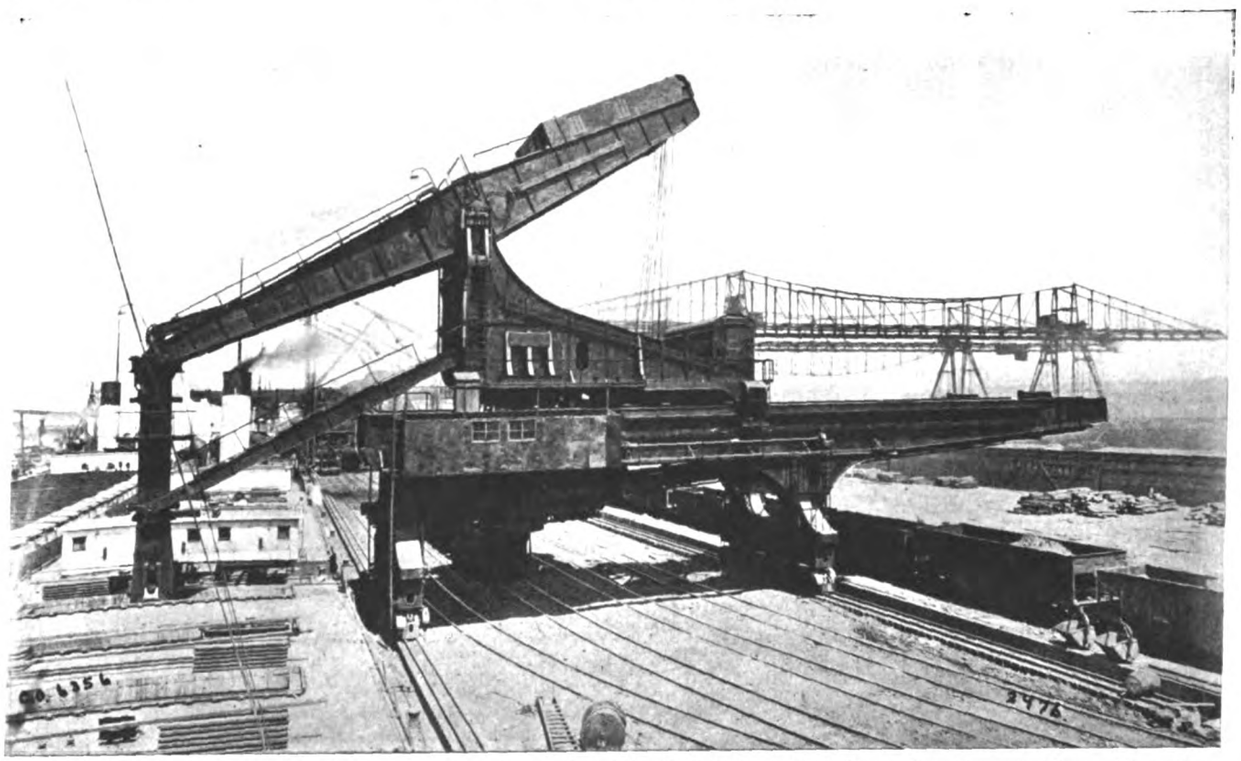

Fig. 2.—Wellman-Seaver-Morgan Unloader Installed at the Docks of the United States Steel Corporation, Conneaut, Ohio. There Are Seven of These Unloaders Installed at This Plant, Some of Which Are Shown in the View Above

to provide machinery for cheap and rapid discharge of cargo from ship to dock or railroad and vice versa, the length of time the ship was tied up to the dock being a vital factor in costs. The result has been a high state of development and concentration of bulk cargo handling plants in the Lakes region.

First Ore Unloaders Installed on the Lakes

In the late nineties the Wellman-Seaver-Morgan Company, Cleveland, Ohio, brought out their ore unloader, each machine capable of handling ore at from 500 tons per hour upward. At about the same time the car dumper, for overturning standard railway cars and dumping their contents, was developed. The latter have been evolved until at present they will handle 30 dumps per hour and upward, some installations handling as much as 3,000 tons per hour of net material, two cars in tandem.

Conditions largely due to the European war caused a more general interest to be developed along our coast line in these methods. Prior to our participation in the war a few installations had been made on the Atlantic Coast, especially in the line of loading cargo and bunker coal. Rising labor costs and necessity of rapid *turn around* on the comparatively few vessels available brought the issue of improved dock facilities to the forefront. It was a question of time, tonnage capacity over a given waterfront, and costs per ton. All the above items in the problem are satisfactorily answered by equipment of the type previously mentioned, and what was still more vital the item of labor in normal volume being unobtainable at any price.

Two Contracts Closed on the Atlantic Coast

Two contracts recently secured by the Wellman-Seaver-Morgan Company on the Atlantic Coast are interesting at this time. A contract with the Lehigh Valley Railroad Company covers an automatic ore unloader carrying a fifteen-ton clam shell bucket on the unloader leg and designed to make a complete cycle or round trip in 50 seconds. The machine electrically operated throughout is illustrated by Fig. 1, and this view, together with Fig. 2, illustrates the general appearance of similar apparatus in action.

The automatic unloader illustrated is unique in design and has proved through many years of service to be eminently successful for unloading ore cargoes from steamers with suitable hatches. Although of immense proportions, the machine has been simplified and the control perfected to a high degree of delicacy in control and operation.

Description of the Unloader

The unloader consists of a main framework mounted on trucks which travel along the runway rails, which are located approximately as shown in the photograph. The main framework extends back beyond the rear runway over a temporary storage pile, where the ore can be discharged if desired. It is then picked up by the ore bridge and carried to the stock pile. Between the front and rear runways, space is provided for railroad tracks where ore carrying cars are placed under the machines and loaded with ore for transportation to the furnace plants. The girders of the main framework form a support for runway rails, on which a trolley travels. This trolley supports a balanced walking beam, from the outer end of which a stiff bucket leg depends. At the lower end of thi leg is the bucket, which is operated by machinery located on the walking beam. All horizontal movements of the bucket are accomplished by means of moving the trolley backward and forward on the girders. The vertical movements of the bucket are accomplished by the operation of the walking beam. The forward portion of the beam being out of balance, the bucket descends by gravity as soon as the brakes of the hoisting mechanism are released.

Only two operators are required for the entire operation

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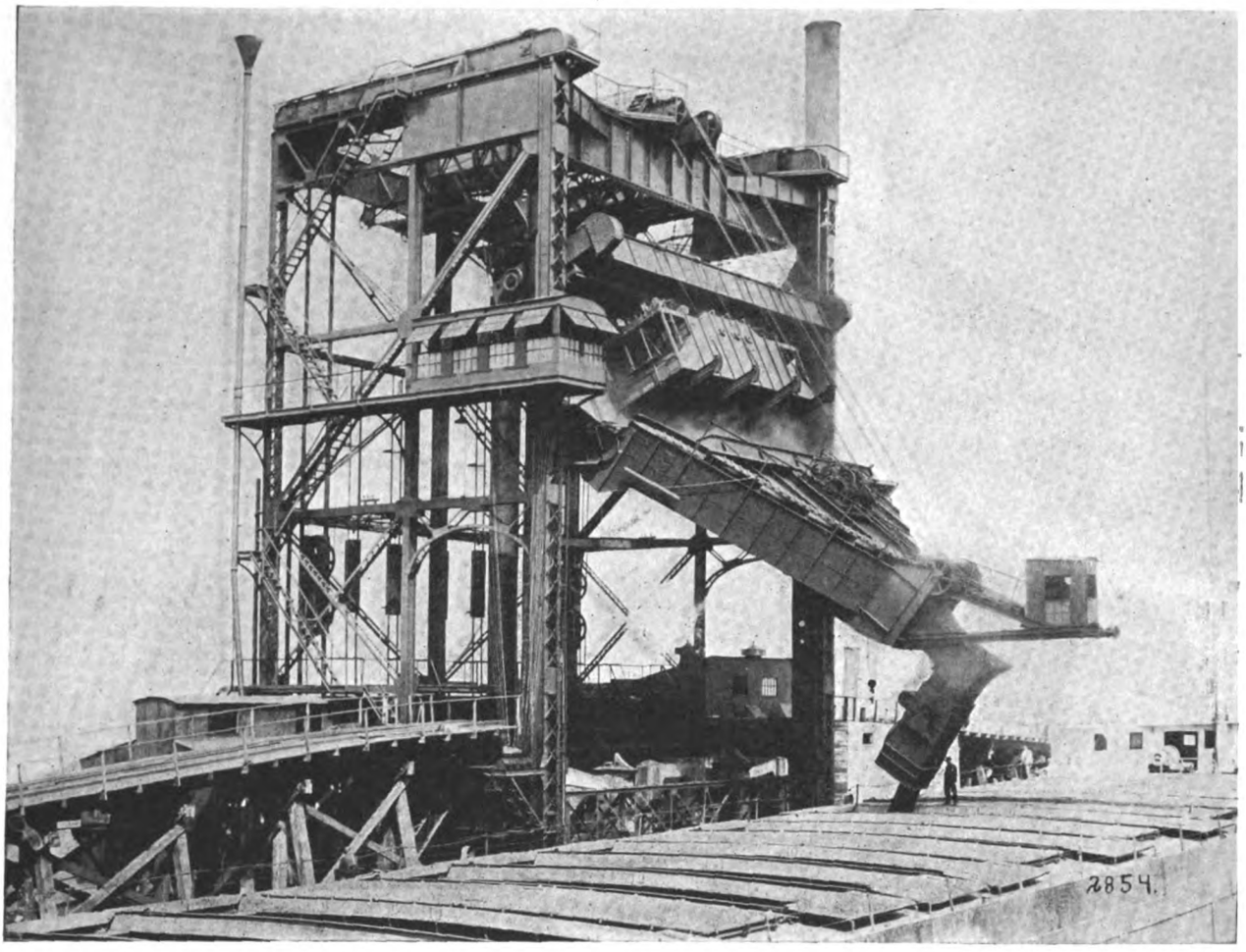

Fig. 3.—Wellman-Seaver-Morgan Lifting Type Car Dumper on the Docks of the Pennsylvania Railroad at Sandusky, Ohio. The Cradle, Containing Car to Be Dumped, is Elevated Before Being Overturned. The Coal is Emptied Into an Adjustable Apron and Chute, Which Are so Designed as to Load the Coal Into Boats With a Minimum of Breakage

of one of these machines. One of the operators, whose station is in the bucket leg directly over the bucket shells, controls all of the motions of raising and lowering the bucket, of traveling the trolley back and forth, and moving the machine along the dock from one hatch to another. The second operator is stationed in a cab on the larry, and from this station he controls the movements of the larry, the operation of the larry gates, and the weighing of the ore.

Capacities Attained

Some idea of the capacities of unloading by this method may be derived from a record which was made in Ashtabula by eight machines of this type having a capacity of fifteen tons each, unloading seven boats having a total capacity of 70,000 tons in 22 hours actual time. At other points, four machines working in boats having capacities up to 13,000 tons have unloaded these cargoes in about three hours and twenty-five minutes.

In addition to the vertical movement, which is given to the bucket leg by means of the walking beam, it also has a motion of rotation around its vertical axis. This motion is introduced to enable the machine to reach along the keel of the boat and clean up ore between hatches. The distance from point to point of bucket shells when open is approximately 21 feet. About 97 percent of the ore is removed from the boat without hand labor.

Records of fifty machines in operation indicate that this type of machine will handle ore at 2½ to 4½ cents per ton including all fixed charges, and records of as high as 783 tons of ore per hour per machine from tie up to cast off of boat have been made.

The Lehigh Valley Unloader

The Lehigh ore unloader will be installed at the Claremont Terminals, New York Harbor, to handle Chilean and Cuban ore. A cost of pig iron lower than that based on Minnesota ore is predicted due to economies effected.

A contract with the Western Maryland Railroad Company at Port Covington, Baltimore, covers a Wellman car dumper to handle 100-ton road cars. It is the first electrically operated lifting dumper for seaboard coal loading to be negotiated. The lifting feature is designed to raise the road car high enough before overturning to cause the coal to run down the apron and chute into the ship's hold, as illustrated in Fig. 3. Dumping directly to the ship eliminates breakage and waste due to rehandling. The entire cargo is trimmed without the use of hand labor.

Car Dumper for Western Maryland Railroad

The machine consists essentially of a rectangular framework supporting a rotating cradle in which the loaded railroad car is held while discharging. An entirely automatic counterweight device clamps the car to the cradle which is inverted by the revolving mechanism, carrying the car with it. The top of the cradle forms a chute for directing the material as it flows out.

This installation will have a nominal capacity of 30 to 45 cars per hour of cargo and bunker coal, principally for

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export. The coal is delivered to the dumper by the Western Maryland Railroad from the West Virginia, Virginia and Pennsylvania fields. One million tons will be handled annually with a probable increase to twice that capacity later.

These typical plants indicate the essential soundness and progress of our basic industries, and the gradual elimination of hand labor, which is then diverted to more useful and productive work. These plans also indicate that beneath the surface froth of labor unrest and business uncertainty of the day there is a constant current of accomplishment and confidence. The former are merely the phenomena of a business cycle and the latter is the foundation of the country.

Westinghouse Geared Turbines Installed on New Swedish Battleships

EARLY in the coming fall Sweden will try out its two new coast defense battleships, the *Drottning Victoria* and the *Gustaf V*. These vessels are 396 feet long and 64 feet beam. At a draft of 21 feet they displace 7,000 tons and will have maximum speeds of 22½ knots. The main batteries consist of four 11-inch and eight 6-inch guns. The main armor belt is 8 inches thick.

The propelling equipment of each of these ships consists of two Westinghouse turbines, which are rated at 22,000 shaft horsepower and drive the two propellers through floating-frame reduction gears. The turbines were built in accordance with Westinghouse designs by the Motala Verkstads Nya Aktiebolag, at Motala, Sweden, and the gears were designed and built by the machine works of the Westinghouse Electric & Manufacturing Company at East Pittsburgh, Pa.

Each turbine consists of two separate units, rated at 5,500 shaft horsepower each, which drive a propeller through a common gear. Steam from the boiler enters the high pressure unit and passes through a set of impulse blades. It then divides into two parts, one of which continues through the high pressure unit, while the other goes into the low pressure unit. In both units the steam is fully expanded in reaction blading and passes into the condenser through a common discharge.

The chief advantage of this arrangement, which is known as the "divided flow," is that all four units are available for propelling the ship at maximum speeds; but for ordinary cruising speeds, the low pressure units can be cut out and the ship propelled by the high pressure units only. These, being of the complete expansion type, produce low speeds with good economy. Should an accident put a high pressure unit out of commission, the ship can be propelled by the low pressure units, which are designed to receive steam at boiler pressure. When any unit is out of use it usually turns idly in a vacuum, but it can be mechanically disconnected.

The divided flow turbine is not quite as efficient for full speed operation as the cross compound turbine, in which part of the expansion of the steam is effected in the high pressure unit and the rest in the low pressure unit. It is, however, more efficient at low speeds because one unit can be cut out, and this makes it especially applicable to naval service. In addition, it can be operated at somewhat

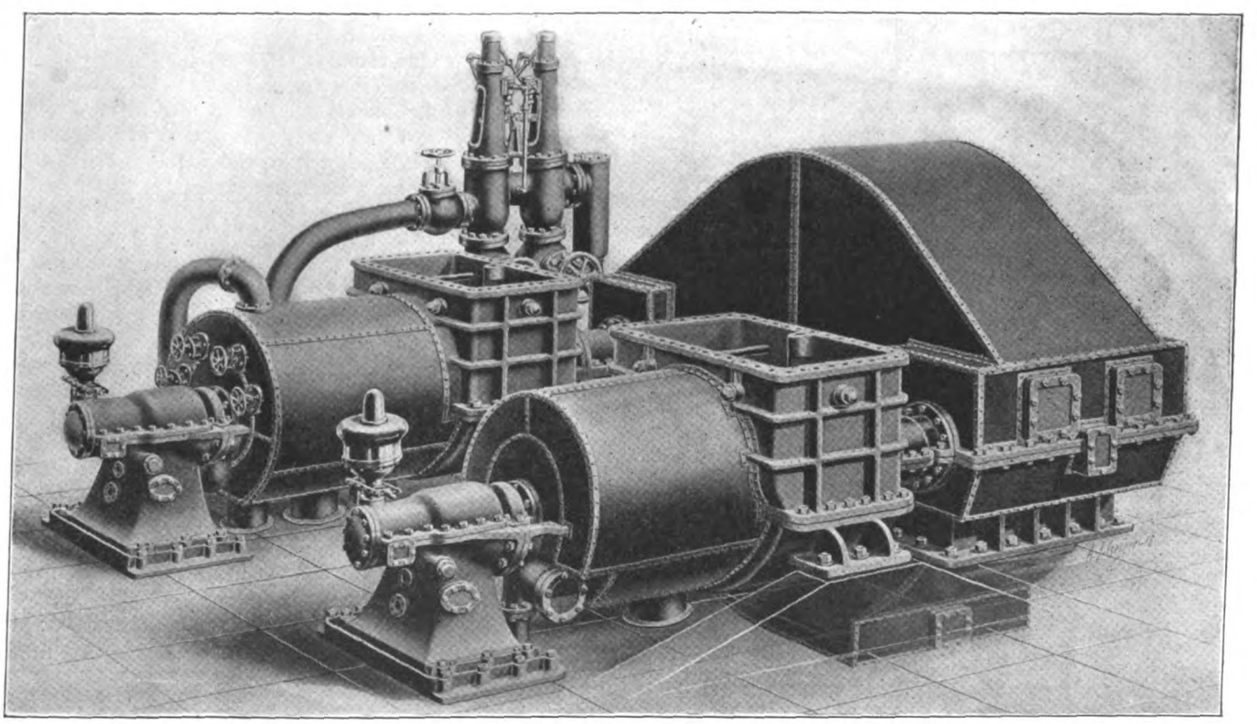

Fig. 1.—Westinghouse Divided Flow, Geared Turbine Used on Swedish Battleships, Showing High and Low Pressure Units, Condenser Exhausts and Gears

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higher speeds, which tends to counterbalance its slightly poorer efficiency.

The performance of the Swedish turbines, with steam at 265 pounds per square inch and a vacuum of 28.27 inches, is as follows:

Speed, knots	22½	20	12½
Propeller revolutions per minute	200	177	115
Turbine revolutions per minute	3,600	3,186	2,070
Shaft horsepower	22,000	15,000	3,150
Steam consumption, pounds per shaft horsepower	10.9	11.1	13.3

The water rate at 12½ knots is for operation with the high pressure units only. Were all four units, lightly loaded, used to obtain this speed, the water rate would be about 17 pounds.

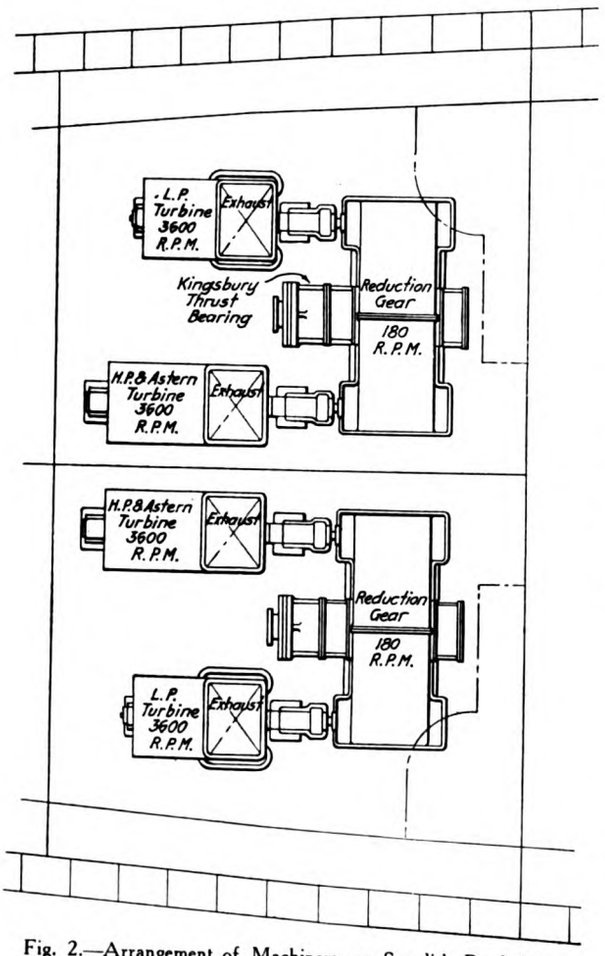

Fig. 2.—Arrangement of Machinery on Swedish Battleship

An astern turbine, composed of impulse blades and giving 4,500 shaft horsepower with full steam flow, is incorporated in each high pressure unit.

The reduction gears reduce the turbine speed of 3,600 revolutions per minute to the propeller speed of 200 revolutions per minute, an 18 to 1 ratio, in a single step. Each has two pinions (one for each unit of its turbine) and one gear wheel. The gears are placed forward of the turbines and the propeller shafts pass aft between the two units of each turbine. Kingsbury thrust bearings take up the thrust of the propellers.

G-R Strainer for Lubricating and Fuel Oil Lines

STRAINERS are required on the suction and discharge lines of lubricating oil, fuel oil and quenching oil systems for the removal of solid foreign material in suspension. Also power plants which secure their raw water supply from such sources as rivers or lakes require strainers to prevent weeds, sticks, marine plants and small fish from entering pipe lines. For this purpose The Griscom-Russell Company, 90 West street, New York, has placed on the market a G-R strainer, the body of which is constructed of cast iron and the strainer basket of perforated sheet steel lined with wire mesh when the strainer is to be used on an oil line. The G-R strainer is of the single type and may be installed either as a single unit or as the G-R strainer set. This G-R strainer set consists of two of these strainers connected complete, including the two 3-way valves and necessary connecting elbows, unions and nipples. This set permits the cleaning of either of the two units without interruption of the service. In addition to the oil strainer unit, the Griscom-Russell Company also produces a multiwhirl type cooler for cooling lubricating oils used in turbine bearings, reduction gears and similar heavy duty work. In this service the oil must be maintained at constant temperature as well as free from impurities.

G-R Strainer, Single Unit Construction

Welded Motorship Fullagar

(*Concluded from page 725.*)

extremely rough weather was encountered, and as this became worse it was found necessary to put into Ramsey until the storm abated. During this part of the voyage the engine ran steadily throughout, no racing being experienced, and there was only a slight variation in the revolutions. The hull was well tested, the force of the waves subjecting it to severe shocks and strains, which it withstood satisfactorily.

The vessel left Ramsey at 4:20 A. M. on July 1 and reached Greenock about 6 P. M. The engine continued to run steadily at a speed of 106 revolutions per minute, the ship making a speed of about 9.75 knots against wind and tide.

On July 2 a party of Clyde shipbuilders and engineers were present and witnessed trial runs on the measured mile, and also maneuvering tests. The *Fullagar* left the Clyde at 11:30 P. M. on the same evening and arrived in the Mersey at 8 P. M. on July 3. The engine ran satisfactorily and without any sign of trouble from start to finish at an average speed of 107 revolutions per minute, the vessel averaging about 10 knots. During this run the fuel consumption worked out to be 2.1 tons per day of 24 hours.

Some of the readings from the engine are as follows:

Scavenge air pressure	1¼	pounds per square inch
Circulating water pressure	6.5	pounds per square inch
Lubricating oil pressure	12	pounds per square inch
Blast air pressure	1,000	pounds per square inch
Scavenge temperature	50	degrees F.
Circulating discharge temperature	100	degrees F.
Engine room temperature	62	degrees F.

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Experience and Practice in Mechanical Reduction Gears in Warships*

BY ENGINEER-COMMANDER H. B. TOSTEVIN, D.S.O., R.N.

The most important change in the steam machinery of warships of high speed and power during the war period was the departure from the direct drive turbine installation to that in which the power of the turbines was transmitted to the propeller shaft through mechanical reduction gearing. It is the object of this paper to trace briefly this development and indicate the experience that has been gained and also the general practice of the British Admiralty as regards the details of these gears.

BEFORE the actual adoption of gearing it had long been recognized that some form of reduction device was necessary in order that the turbines and propellers should run at speeds which secure their best efficiencies, and all designs with the direct drive installations had been of the nature of a compromise in which the maximum efficiencies of both turbines and propellers had been sacrificed in order to obtain the best overall results to meet the nature of the particular case. There were three practical methods of obtaining this reduction, viz., hydraulic, electrical and mechanical, each possessing its peculiar merits, and in the early history it is noteworthy that the first two were more seriously considered than the third, as they did not at the time offer such difficulties in the way of manufacture and reliable transmission of high power. At the present stage in British naval practice the first two methods have not been tried, at least in connection with high power steam machinery.

Whatever method is adopted, a loss must occur between the turbines and the propeller shaft from various causes, which need not be gone into here. Experiments have shown that with the best design of the respective devices the losses in transmission may be approximately taken as: hydraulic, 10 percent; electrical, 8 percent; mechanical gearing, 1½ percent. If double reduction gear were fitted, the loss with mechanical gear would be about 3 percent.

The superior efficiency of the mechanical method has been an important factor in reaching a decision as to the type of reduction device to be adopted for naval use, and when it is combined with considerations of simplicity and reliability and the very small cost of upkeep, the combination has been considered up to the present to outweigh the advantages possessed by the other forms of transmission, such as the absence of astern turbines and the possible maintenance of a higher turbine speed and efficiency at cruising speeds. With the design of turbine as now developed, in which special arrangements are made to permit it to maintain its efficiency to a marked extent as the speed of revolution falls, this latter advantage is to a certain extent discounted.

The endurance and reliability which are features of turbine installations are even more pronounced when geared turbines are fitted, because of the smaller and more rigid structures and moving parts. Also, the larger and more efficient propellers improve the maneuvering power, and in particular the stopping effect is increased by the ease with which the larger propellers get a hold on the water. The necessary astern power (which in most warships is approximately one-third of the ahead power) can be obtained on a single velocity compounded turbine wheel without working the boilers to full power. The smaller turbines and their more substantial construction render them less liable to distortion troubles than is the case with the larger direct connected units.

To trace the development of mechanical gearing for marine purposes one need go back no further than 1910, when Sir Charles Parsons, who was desirous of applying the steam turbine to vessels of moderate and low speed, carried out his experiments in the *Vespasian*, an old cargo steamer, experiments which have proved to be epoch-making. The success of these experiments, which were dealt with in a paper read before this Institution in 1910,† indicated that increased efficiency could also be obtained by means of reduction gearing in ships of the classes from which the reciprocating engine had been definitely displaced by the turbine. The Admiralty made its first step in 1910, and in two topedo-boat destroyers of that year's programme, the *Badger* and *Beaver*, gearing was fitted for part of the main turbine installations. The low pressure turbines drove the shafts direct, but on a forward extension of their rotor spindles gear wheels were fitted which were driven through pinions by the small fast running cruising and high pressure turbines. The maximum horsepower transmitted through each set of gearing was about 3,000. Before these vessels were completed a further advance was made, and in 1912 it was arranged, in two torpedo-boat destroyers, the *Leonidas* and *Lucifer*, of 22,500 horsepower, for the whole power to be transmitted through two sets of gearing. The general arrangement as regards the component parts of an all-geared set adopted in these vessels has been adhered to in naval practice to the present day, viz., each set of gearing is driven by two pinions, driven respectively by the high pressure and low pressure turbine. In some installations an additional turbine for cruising has been fitted on an extension of the high pressure spindle.

On completion of the *Leonidas* in 1914 exhaustive trials were carried out, and the results obtained as regards the efficiency of the machinery installation at all powers were very satisfactory and superior to any that had been obtained with direct drive units. Both vessels were hurriedly put into commission in August, 1914, when experience with the running of high powered gears was practically nil. The installations received a very severe test on service, as both boats were in commission right through the war, for the first two years being attached to the hard-worked Harwich force. Their successful running speaks volumes for the manner in which several recognized difficulties connected with the application of mechanical reduction gears for high powers had been so quickly recognized and overcome.

Before the completion of the *Leonidas* and *Lucifer*, two light cruisers of 40,000 horsepower, viz., *Calliope* and *Champion*, were arranged to have all geared units, but

* Paper read before the Institution of Naval Architects, London, March 26, 1920.

† Transactions, Institution of Naval Architects, Volume LII, page 168.

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the former vessel was fitted with four shafts and the latter with two, so it is seen that in the course of three years from the adoption of reduction gearing, and in the third order of warship so fitted, a figure of 20,000 horsepower through one set of gearing was reached. This installation ran satisfactorily on service, and as a result it was recognized that mechanical gears were suitable for the highest power required on a single propeller shaft.

The all-geared installations were not at once universally adopted for the vessels ordered on the earlier war programmes, the policy in the emergency of adhering to the direct drive type of turbine, which for several years had proved its efficiency and reliability, being followed for some time. The subject of gearing was, however, by no means ignored, and all warships ordered were fitted with cruising turbines, which were geared to the direct drive units. Clutches were arranged to disengage these gears when running at high powers, although this procedure was not absolutely necessary. A marked gain in economy within the limits of power of the cruising turbines, and a consequent increase in the radius of action was obtained. It should also be understood that at this time the number of special "hobbing" machines required for cutting the teeth of these gears was very limited, and it would not have been possible at the time to have fitted all the war vessels ordered with the all-geared type of installations. By 1916, however, it was considered that sufficient progress had been made to warrant the complete change over, and in practically all fast warships, viz., battle cruisers (a number of which were subsequently not proceeded with) designed to transmit 36,000 horsepower through each set of gearing, light cruisers, flotilla leaders, torpedo-boat destroyers, "K" class submarines, and "P" boats, the all-geared installation was adopted. Only in the case of a few special destroyers was the direct drive adhered to.

The following table shows the total horsepower and number of all-geared sets fitted and being fitted in warships:

Type of Vessel	Shaft Horsepower	Number of Shafts	Shaft Horsepower per Gearing Set	Total Number of Gears	Total Shaft Horsepower
Battle cruiser	144,000	4	36,000	4	144,000
Light cruisers	40,000–80,000	2 or 4	10,000–20,000	50	1,760,000
Flotilla leaders	40,000	2	20,000	26	520,000
Torpedo-boat destroyers	27,000–30,000	2	13,500–15,000	368	5,000,000
"K" Class submarines	10,000	2	5,000	36	180,000
"P" and "P.C." boats	3,500	2	1,750	128	224,000
Totals				612	7,828,000

Of this number, 556 gears are, or have been, on service, representing 6,794,000 shaft horsepower. The 36,000 shaft horsepower sets have not yet been on service, but have run at approximately full power for a short period.

In addition there are a large number of sets of gears fitted in conjunction with cruising turbines, or as part installations, but as these gears, owing to the exigencies of war and other conditions, have not been used to their full extent, they are not included in the list.

The arrangements of turbines and gearing in typical vessels are shown in Figs. 1 to 8.

In straight cut gears the small number of teeth in contact, viz., one or two, imposes a limit to the speed at which high powers can be smoothly or safely transmitted, and for transmitting high power, helical gear, i. e., toothed wheels in which the teeth are inclined to the axes of the wheels, is necessary. All the gearing now in use in warships is of the double helical type, a right and left hand helix being used to balance the axial thrust entailed. The involute tooth form is invariably used, as it possesses essential advantages over other forms, the most important of which are:

(1) The teeth can be generated automatically in a machine by a straight sided cutting tool, which can be made and ground very accurately.

(2) A variation in distance between the centers of pinion and wheel (and such variations occur in marine practice owing to the necessity for ample clearance in the high speed bearings, and also possibly with misalinement and wear of bearings) does not affect the velocity ratio of the wheel and pinion or the smooth working of the teeth.

In the early days of turbine gearing there was not much experience available bearing on helical gearing for comparatively high powers, and in the first designs the gears were arranged with a helical angle of 20 degrees in conjunction with a pitch normal to the line of the teeth of ¾ inch. This design was rather noisy, and in consequence the angle in succeeding designs was increased to about 45 degrees, which value was known to have proved satisfactory in DeLaval installations of small power. The 45-degree design was continued until recently with generally satisfactory results, but in the meantime, with the improvements in gear cutting processes, it had gradually been established that the noise and tremor experienced in the early installations was more due to irregularities in cutting than to the small helical angle itself. An angle of 30 degrees, which possesses advantages in the way of efficiency and tooth strength, in that the effective contact between the teeth is increased as compared with 45 degrees, while the normal load on the teeth is decreased, has now been generally adopted by the Admiralty. This angle is rarely an exact number of degrees, as it is affected by the driving and change wheel mechanism of the hobbing machine, but is as near the desired angle as these details allow.

The angle of obliquity used is 14½ degrees, in agreement with the almost universal commercial standard developed for spur gearing with involute teeth. There is no particular virtue in this angle within limits, and the odd ½ degree, it is understood, was decided by the fact that sine 14½ degrees being 0.250, calculations were simplified.

Fine pitched gears give more silent running at high speeds, and a normal pitch of 7/12 inch has been adopted for all but the very largest installations. While the pitch and obliquity have remained the same, the proportion between addendum, dedendum and pitch respectively and the shape of the root and tip have been changed from time to time as experience of the successive designs was gained. Fig. 9 illustrates stages of the transition, it being noted that the form of cutting tool is shown, and that while the height and normal pitch of the actual tooth generated will be the same as for the hob, the thickness and contour of the teeth will depend upon the pitch circle diameter and upon the hob design. The earliest design of hob (which is not shown) produced a form which gave at the base of tooth only a small radius, and it was at a very early stage modified to provide a more pronounced radius at the tooth root. In the design in Figs. 9*b* and 9*c* the rounding of the tips of the teeth was introduced to overcome the "digging in" and excessive wear of the tips which had been observed in some designs, probably due to the failure of the oil film on the surface at this position.

The question of the lubrication of the teeth is very important, and while running an ample amount of oil, which is generally injected from nozzles onto the line of contact of the teeth, is necessary. It is usual to arrange ¼-inch to ⅜-inch nozzles of about 5-inch pitch, discharging the

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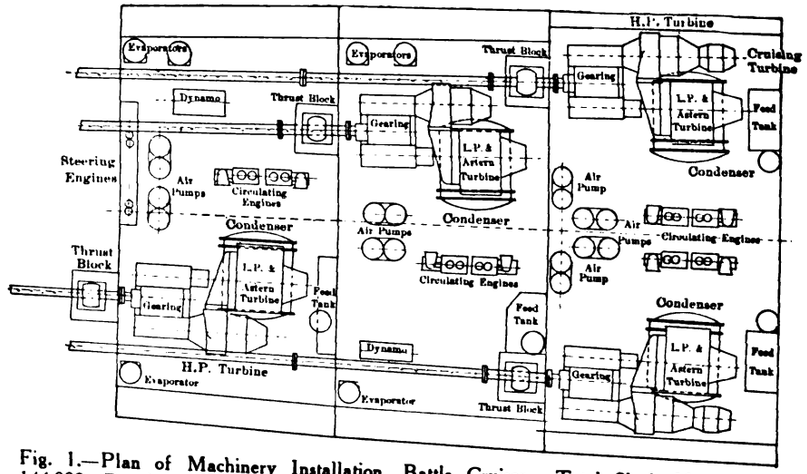

Fig. 1.—Plan of Machinery Installation, Battle Cruiser. Total Shaft Horsepower, 144,000; Revolutions of Propeller Shafts, 210; Revolutions of High Pressure Turbines, 1,497; Revolutions of Low Pressure Turbines, 1,096

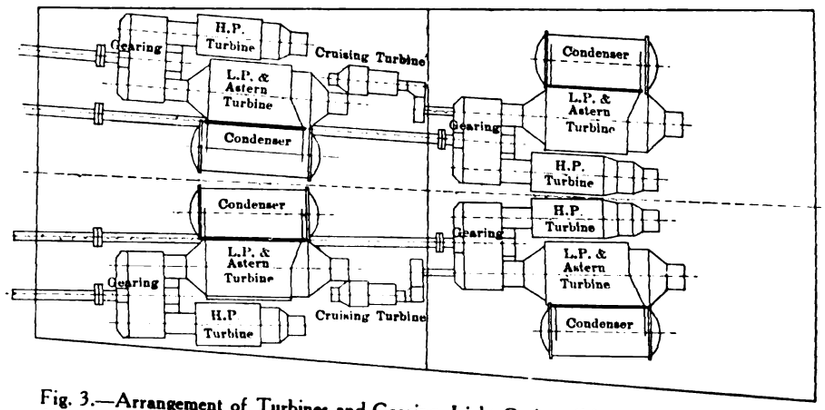

Fig. 3.—Arrangement of Turbines and Gearing, Light Cruiser (H. M. S. *Calliope*). Total Shaft Horsepower, 40,000; Revolutions of High Pressure Turbines, 3,000; Revolutions of Low Pressure Turbines, 1,750; Revolutions of Propeller, 450

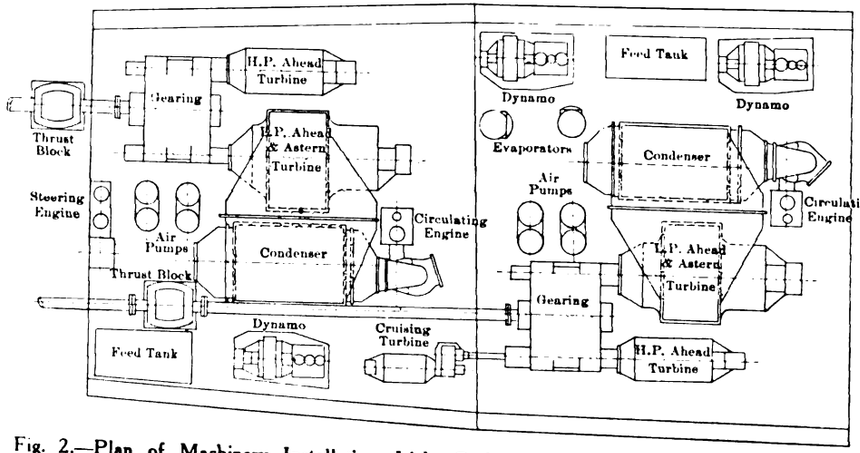

Fig. 2.—Plan of Machinery Installation, Light Cruiser. Total Shaft Horsepower, 40,000; Revolutions High Pressure Turbines, 2,600; Revolutions Low Pressure Turbines, 1,435; Revolutions Propeller Shafts, 340

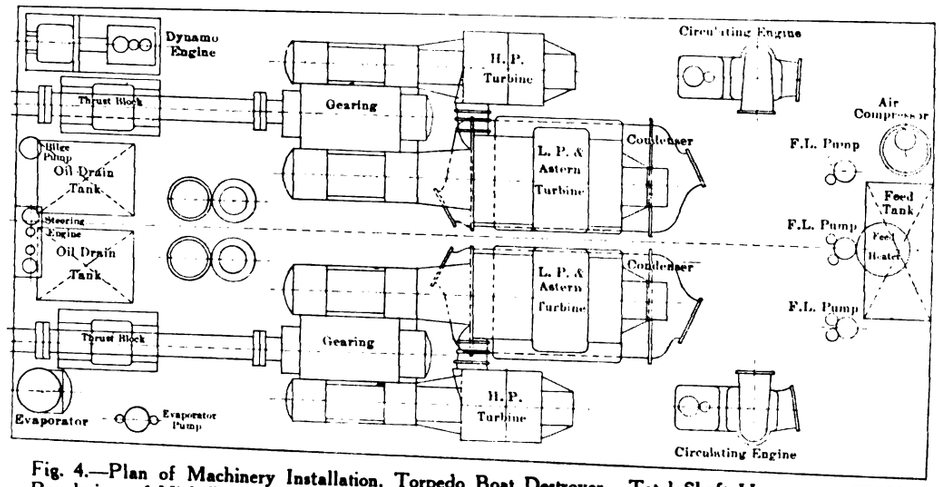

Fig. 4.—Plan of Machinery Installation, Torpedo Boat Destroyer. Total Shaft Horsepower, 27,000; Revolutions of High Pressure Turbines, 2,985; Revolutions of Low Pressure Turbines, 2,262; Revolutions of Propeller Shafts, 350

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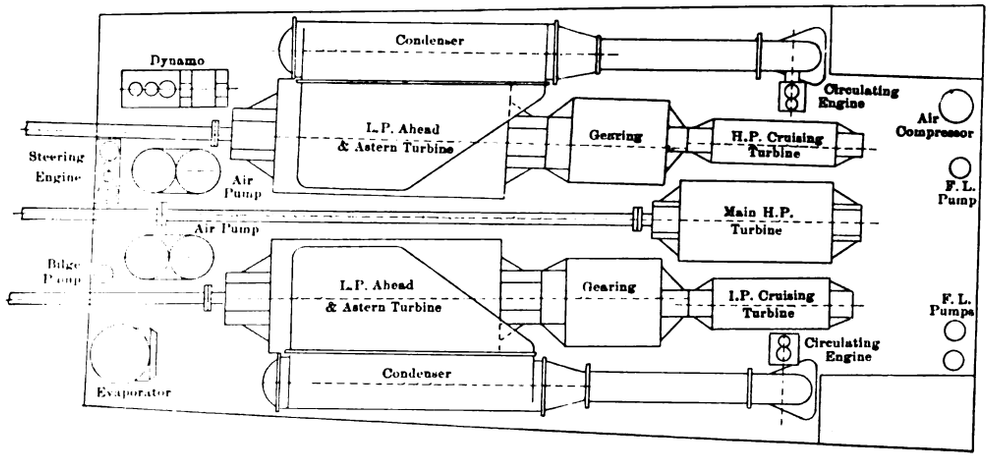

Fig. 5.—Plan of Machinery Arrangement, Torpedo Boat Destroyer With Geared Cruising Turbines. Total Shaft Horsepower, 25,000; Revolutions of High Pressure and Low Pressure Turbines and Propeller Shafts, 750; Reduction Ratios: High Pressure Cruising Turbine, 6.0; Intermediate Pressure Cruising Turbine, 6.0

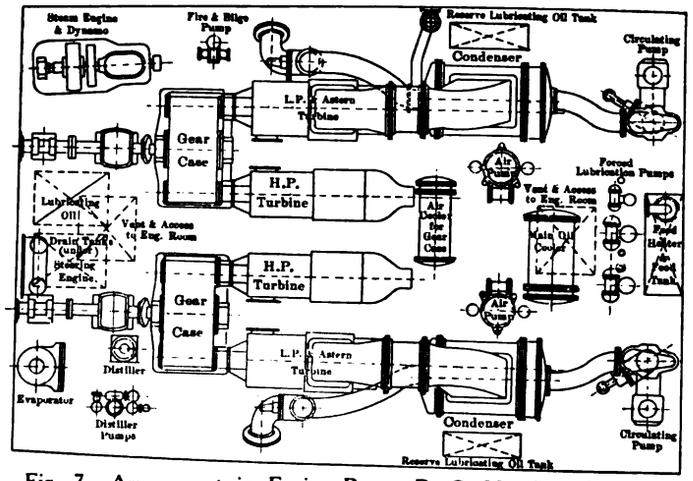

Fig. 7.—Arrangement in Engine Room, P. C. Vessels. Total Shaft Horsepower, 3,500; Revolutions of Turbines, 3,500; Revolutions of Propeller Shafts, 300

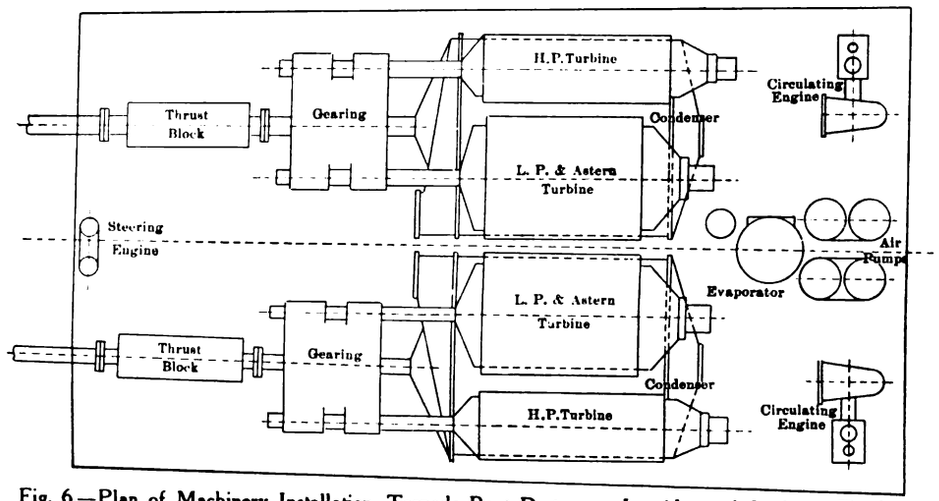

Fig. 6.—Plan of Machinery Installation, Torpedo Boat Destroyers *Leonidas* and *Lucifer*. Total Shaft Horsepower, 22,600; Revolutions of High Pressure Turbines, 3,350; Revolutions of Low Pressure Turbines, 1,800; Revolutions of Propellers, 380

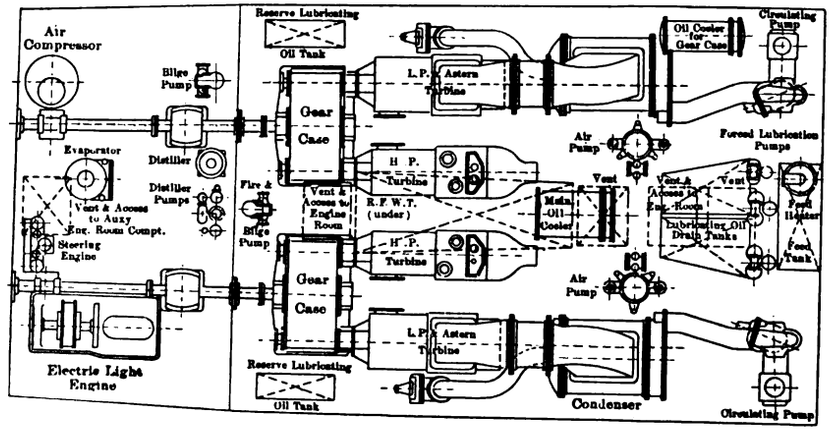

Fig. 8.—Arrangement in Engine Room, P. Vessels. Total Shaft Horsepower, 3,500; Revolutions of Turbines, 3,500; Revolutions of Propeller Shafts, 300

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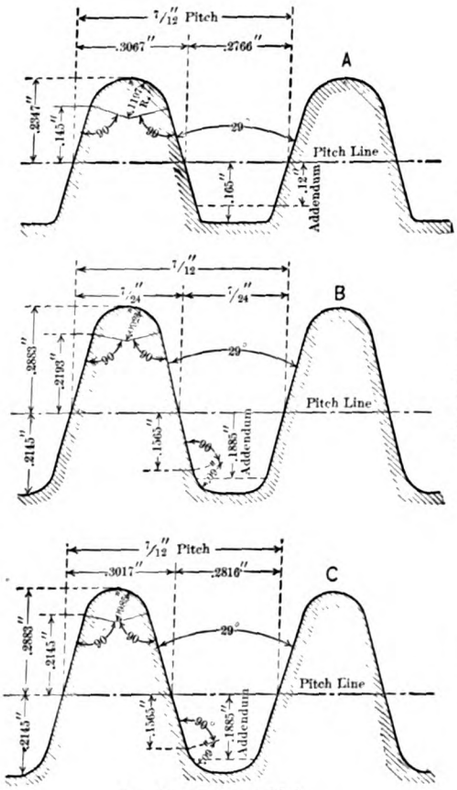

Fig. 9.—Typical Hobs

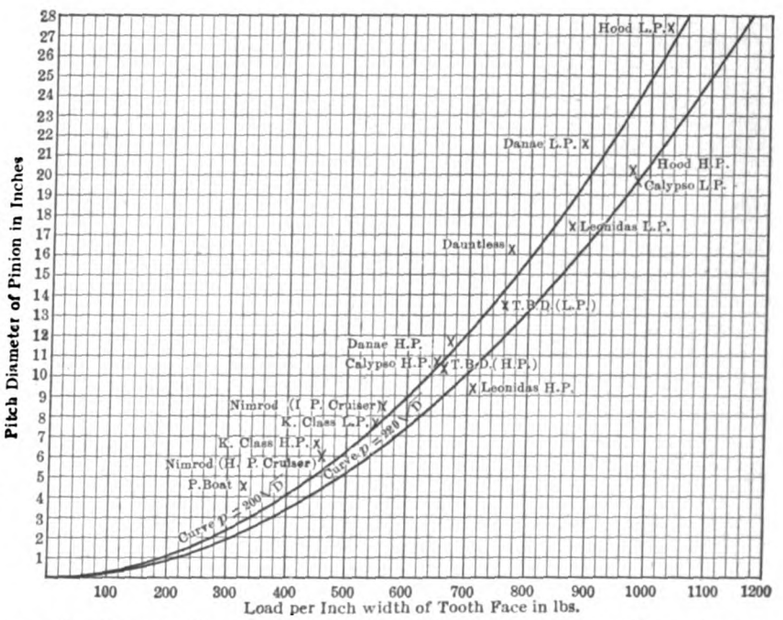

Fig. 10.—Diagram Illustrating Relation Between P. C. D. of Pinion and Tooth Pressure Per Inch Width for Typical Cases Compared With Curves $p=200\sqrt{D}$ and $p=220\sqrt{D}$

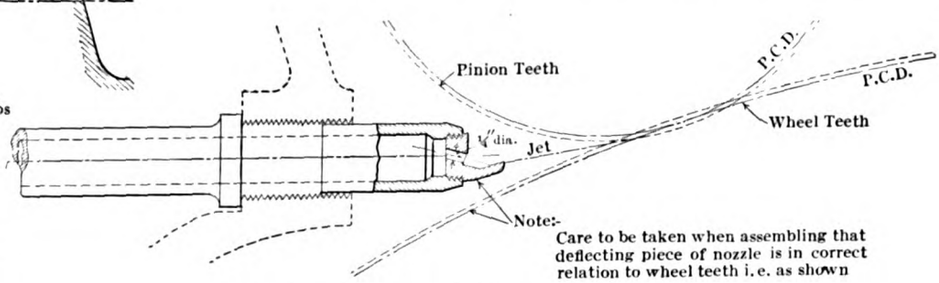
Pinion Teeth
P.C.D.
P.C.D.
Wheel Teeth
¼" dia. Jet
Note:-
Care to be taken when assembling that deflecting piece of nozzle is in correct relation to wheel teeth i.e. as shown

Fig. 11.—Sprayer for Lubricating Gearing Teeth

oil under a pressure of from 5 to 10 pounds, the jet being fan-shaped, so that the whole length of the teeth is lubricated. In early practice nozzles were fitted to discharge to the line of contact both on the entering side when running ahead and also when running astern, but the latter groups are not now fitted, as experience shows they are not required, considering the short periods of astern working usual in naval vessels.

Figs. 11 and 12 show a type of sprayer fitted, together with its arrangement on the gear case.

The teeth of gearing engage by line contact, but it must be appreciated that contact under a load can no more occur on a line than the load on a ball bearing can occur on a number of geometrical points. Elastic deformation of the surfaces must take place under the load, and the momentary flattening leads in each case to a surface contact. Owing to the lubrication, however, the load that can be safely sustained between two sliding surfaces in contact is decided by the pressure in the oil film between them and by the area of the film. Modern developments in the theory of lubrication seem to show that the pressure in an oil film between two surfaces varies as the thickness of the film, and that beyond a certain thickness of film no pressure is maintained. For a given thickness of film it will extend over an area practically proportional to the square root of the radius of curvature of the surface, and this area may be regarded as the virtual area of tooth contact. The radius of curvature may be taken on the pinion teeth alone, as the gear wheel teeth are sensibly flat, and as this average radius

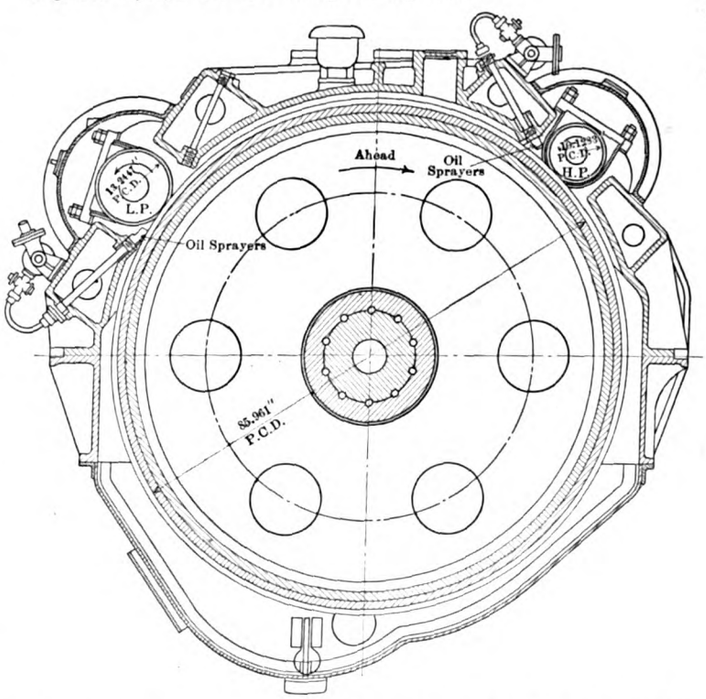

Fig. 12.—Section Through a Gear Case for a Torpedo Boat Destroyer, Showing Relative Positions of Pinions and Wheel and Lubricating Arrangements for the Teeth

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TABLE I.—SHOWING PARTICULARS OF GEARING IN TYPICAL VESSELS

		Battle Cruiser	Light Cruisers			Torpedo-boat Destroyers				"K" Boat	"P" Boat	Flotilla Leader (Geared Cruisers)	
		Hood	*Danæ*	*Dauntless*	*Calypso*	*Seafire*	*Romola*	*Trinidad*	*Leonidas*			*Nimrod* H.P.C.	*Nimrod* I.P.C.
Horsepower	H.P.	17,500	8,600	10,000	8,000	6,250	6,250	6,250	5,150	2,250	875	1,250	3,580
	L.P.	18,500	11,400	10,000	12,000	7,250	7,250	7,250	6,100	2,750	875	—	—
Revolutions per minute	H.P.	1,497	2,568	1,800	2,662	2,985	2,970	3,000	3,340	3,300	3,500	2,380	2,850
	L.P.	1,098	1,403	1,800	1,435	2,262	2,270	2,290	1,815	3,000	3,500	—	—
	Propeller shaft	210	275	275	340	350	350	350	380	380	300	342	483
Pitch circle diameter in inches	H.P. pinion	20.174	11.755	15.319	10.728	10.0694	10.1283	10.101	9.603	6.7526	4.60	6.018	8.111
	L.P. pinion	27.51	21.514	15.319	19.886	13.2830	13.2447	13.2176	17.648	7.5316	4.60	—	—
	Gearwheel	143.787	109.789	99.897	83.991	85.9114	85.961	85.988	84.348	58.9552	53.862	41.864	48.405
Addendum of teeth, inches		0.266	0.1855	0.1855	0.12	0.12	0.12	0.284 Pinion / 0.048 Wheel	0.1855	0.12	0.168	0.1855	0.1855
Number of teeth	H.P. pinion	55	53	71	41	47	39	39	37	26	24	23	31
	L.P. pinion	75	97	71	76	62	51	51	68	29	24	—	—
	Gear wheel	392	495	463	321	401	331	332	325	227	281	160	185
Pitch, in inches	Normal	0.99847	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.583	0.5196	0.583	0.583
	Circular	1.153319	0.69679	0.67783	0.8220	0.6730	0.815875	0.8156	0.8153	0.8158	0.600	0.822	0.822
	Axial	2.002	1.06	1.4285	0.8275	1.16	0.835	0.836	0.834	0.835	1.04	0.822	0.822
Helical angle		29° 57′	33° 12.4′	30° 40.3′	44° 49.8′	29° 58.9′	44° 23.6′	44° 25′	44° 22′	44° 23.6′	30°	44° 49.8′	44° 49.8′
Tooth angle	Normal	14° 28.7′	14° 29.5′	14° 29.5′	14° 29.5′	14° 29.5′	14° 29.5′	14° 29.5′	14° 29.7′	14° 29.5′	17° 30′	14° 29.5′	14° 29.5′
	Circular	16° 36′	17° 12′	16° 44′	20° 2.5′	16° 37.5′	19° 57′	19° 55′	19° 56′	19° 57′	20°	20° 6′	20° 6′
Width of pinion face, in inches	Total	75	53	60	54	40	40	40	29	28	21	24	35
	Effective	73.25	51.25	58.25	52.6	38.25	39.5	38.6	27.6	26.9	20.5	24	35
Number of teeth engaging		36.60	48.3	51.7	63.5	33.0	46.7	46.2	33.1	32.2	19.71	29.2	42.6
Length of tooth contact, in inches, per tooth	H.P.	3.525	2.125	2.38	0.94	1.58	0.97	1.21	1.46	0.9625	1.79	1.337	1.39
	L.P.	3.63	2.185	2.38	0.94	1.58	0.97	1.21	1.51	0.9625	1.79	—	—
Total length of contract, in inches	H.P.	128.8	103.3	123.0	59.7	52.2	45.3	55.9	48.4	31.0	35.30	39.08	59.2
	L.P.	132.9	105.5	123.0	61.3	52.2	45.3	55.9	49.9	31.0	35.30	—	—
Tangential load, in pounds	H.P.	73,000	35,850	45,700	35,200	26,200	26,200	26,200	20,300	12,700	6,840	11,000	19,500
	L.P.	77,200	47,500	45,700	53,000	30,500	30,500	30,500	24,040	15,400	6,840	—	—
Normal load, in pounds	H.P.	87,000	44,400	55,000	51,500	31,300	38,000	38,100	29,350	18,400	8,300	16,150	28,600
	L.P.	92,600	58,700	55,000	77,500	36,300	44,000	44,100	34,800	22,300	8,300	—	—
Load in pounds per inch, tooth length of contract	H.P.	675	430	449	871	600	838	681	606	594	234	413	483
	L.P.	697	556	449	1,260	695	970	790	697	720	234	—	—
Load, per inch, on total width of tooth face in pounds (=P)	H.P.	965	677.5	762	650	655	655	655	701	453	325	458	557
	L.P.	1,030	896.0	762	980	760	760	760	830	550	325	—	—
K in formula $P = K\sqrt{P.C.D.}$	H.P.	215	197.5	195	198	206	207	206	226	174	152	187	196
	L.P.	196	193.0	195	220	208	207	208	198	200	152	—	—
Speed of teeth at pitch line in feet per second		132	132	120.4	124.8	131	131	131	140	97.6	70.0	62.5	101
Maximum rubbing velocity of teeth in feet per second	H.P.	11.5	14.6	10.5	8.5	11.5	8.9	18.9	9.5	11.0	15.5	12.1	14.5
	L.P.	9.5	8.3	10.5	4.9	7.2	6.2	14.4	16.9	11.0	15.5	—	—
Stress at root, in pounds per square inch	H.P.	3,040	3,530	3,540	5,850	4,150	5,680	—	4,980	4,000	1,900	3,900	4,740
	L.P.	3,140	4,580	3,540	8,500	4,820	6,680	—	5,720	4,850	1,900	—	—

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of curvature of the tooth form varies as the pitch diameter of the pinion, an empirical rule depending to a certain extent on the helical angle for the allowable tooth pressure $p = K\sqrt{D}$, where K is constant, is obtained, p being the intensity of pressure in pounds per inch of axial length. The values of K for a large number of cases are shown in Table I and are seen to be round about 200-225 in the majority of cases. The pressures obtained per inch width of face are also shown, and vary from 700 to 1,030 in the high powered installations at the nominal full power. Table I and Fig. 10 illustrate these points in typical cases.

(To be concluded.)

New Docking Facilities at San Francisco Plant of Bethlehem Shipbuilding Corporation

THE Union plant of the Bethlehem Shipbuilding Corporation, Limited, or the "Union Iron Works," as it has been known for thirty-five years or more, has always enjoyed the highest reputation for economy, efficiency and speed on all types of ship repairs and construction work. This has been due to its superior waterfront facilities, its modern equipment and efficient personnel. With the completion of the waterfront improvements now under construction and the recent acquisition of the new 12,000-ton floating dry dock, the facilities and equipment of this plant easily surpass those of any other shipyard on the Pacific Coast and are unsurpassed by few yards in the world.

12,000-Ton Floating Dry Dock

The new 12,000-ton floating dry dock was purchased from the Ames Shipbuilding Company, of Seattle, just prior to its completion by that company. It is now being towed down to the Union plant on San Francisco Bay and is expected to be in full operation by September 1. The dock consists of four sections of 3,000 tons capacity each: each section being 90 feet long and 126 feet wide, both end sections having an apron of 27 feet, the interval between the sections being 2 feet 6 inches or a total length over aprons of 421 feet 6 inches. It has a depth of 27 feet over the keel blocks, and with the exception of a few battleships now on the Pacific Coast it is able to handle all ships that normally come into the harbor of San Francisco.

Location of the Dry Docks

In order to concentrate its floating dry docks, the No. 3 dock will be moved to the Potrero Works from the Alameda Works; this will give the Potrero Works the following floating dry docks:

No. 2.—270 feet 0 inches long, 66 feet inside width, 2,000 tons capacity.
No. 3.—301 feet 0 inches long, 68 feet inside width, 2,500 tons capacity.
No. 4.—450 feet 0 inches long, 80 feet inside width, 6,500 tons capacity.
No. 5.—420 feet 11 inches long, 90 feet inside width, 12,000 tons capacity.
(All of these docks are operated by electricity.)

The Alameda plant will have:

No. 1.—Marine railway, 320 feet 0 inches long, 70 feet wide with 4,000 tons capacity.
No. 2.—Marine Railway, 220 feet 0 inches long, 60 feet wide, with 2,000 tons capacity.
(The marine railways are operated by steam.)

Hunter's Point will have:

No. 2.—Graving dock, 750 feet long, 103 feet wide at the top and 86 feet wide at the bottom.
No. 3.—Graving dock, 1,020 feet long, 153 feet wide at the top and 110 feet wide at the bottom.

(The equipment for No. 2 graving dock is operated by steam, and that for No. 3 dock by electricity.)

The graving docks are cut out of solid rock and lined with concrete.

No. 3 graving dock is one of the largest in the world. It will handle with ease the largest ship afloat, either merchant or naval. It is so designed that it will receive any ship that is capable of passing through the Panama Canal.

It is just as essential to have sufficient lineal mooring capacity as it is to have a large number of dry docks and marine railways. The Union plant is not lagging behind in this most essential requisite. The relation between wharfage and dry dockage has always been maintained and is now being increased due to the purchase and addition of the new docks.

New Wharves and Extensions

Wharf No. 5 is being extended 320 feet and a new wharf is being constructed 587 feet long and 60 feet wide, parallel to and 200 feet distant from wharf No. 5. This wharf is an extension to the present system and connects with the other wharves and the plant proper by a wharf 50 feet wide.

This new wharfage construction will provide an additional 60,000 square feet of wharfage, all of which has been designed to carry a load of 500 pounds per square foot. The lineal mooring capacity will be increased by approximately 2,500 feet, giving six additional berths or a grand total of twenty-one.

At the Alameda plant the present bulkhead wharf will be extended 400 feet, making it 1,300 feet in length. A new fireproof electric sub-station is being constructed as well as a new paint shop, a building for the employment department and a hospital.

At Hunter's Point the wharf at the entrance to No. 2 graving dock will be entirely reconstructed.

New Piers Built of Creosoted Piling

It is noteworthy that these new piers are being built throughout of creosoted piling. To those unfamiliar with the devastation of marine life on the Pacific Coast, particularly the borings of the teredo, that statement may mean little: the fact is, however, that green piling has a life of about two years, whereas creosoted piling will endure indefinitely. With a creosote impregnation of twelve pounds to the square foot and penetration of one-half to three-fourths inch, the piling is immune to the attacks of the teredo, provided that the surface of the piling is not broken so as to expose impregnated wood. In brief, the Union plant aims at permanency in this new work.

The railway system will be extended so as to serve all the new wharves under construction. These wharves will be piped for air, steam, water, and a complete electric wire system of the most modern construction will be installed.

In addition to its dry docks and wharves, the Union plant's complete facilities are unsurpassed on the Pacific Coast. It has seventy modern fireproof buildings of 1,500,000 square feet of floor space all equipped with modern machinery, three shear legs, three work barges, tugs and launches, and the largest stock of material carried by any shipbuilding plant on the Pacific Coast.

Ship Repair Record of the Union Plant

Besides its wonderful record in the construction of merchant and naval vessels which is known throughout the world, it has repaired or dry docked not less than 2,500 vessels in the past thirty-two months, a record that speaks well for San Francisco Bay shop facilities and the Union plant.

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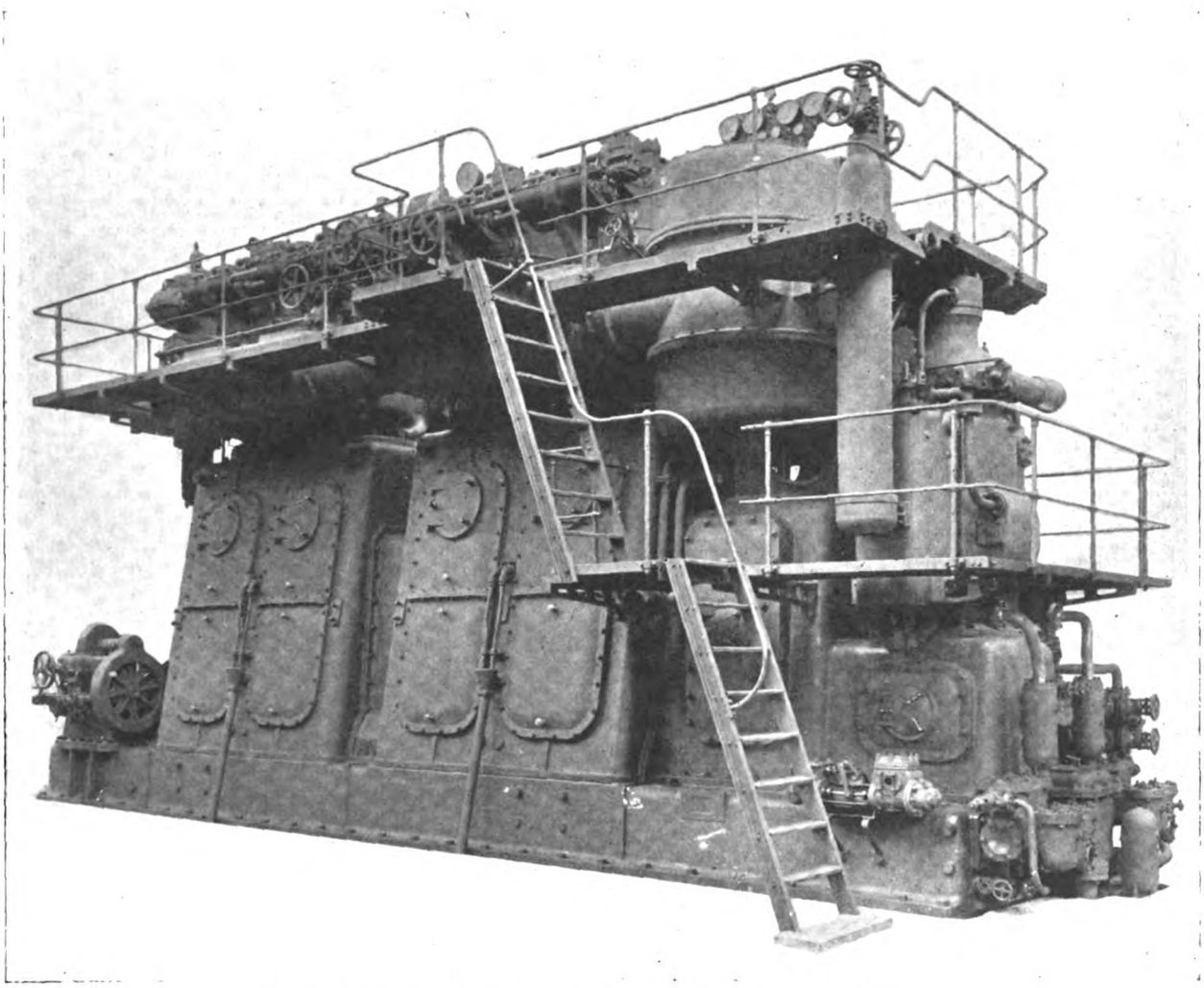

Fig. 1.—1,100 Brake Horsepower Marine Type Busch-Sulzer Diesel Engine

The Busch-Sulzer Diesel Engines

BY C. H. PEABODY, DR. ENG.

These engines are operated on the two stroke cycle, the scavenging and charging air being admitted through ports in the cylinder liner, so that only the fuel valve is required to be fitted in the cylinder head. Simplicity, reliability, reduction in size, weight and cost as compared with the four cycle type and the ability to burn low grade and impure oils are the advantages claimed for these engines.

THE first successful Diesel engine was completed by Dr. Rudolph Diesel in 1897, and his engine has in a quarter of a century been developed and stabilized in its various types and for many purposes. In 1898 the first American Diesel engine was built in Saint Louis by the company which is now known as the Busch-Sulzer Brothers Diesel Engine Company of that city. That company has partnership affiliation with the Sulzer Freres of Winterthur, Switzerland, and has the advantage of their experience in manufacture of many Diesel engines and of their experimental investigations of engines of various types, including an engine which develops 2,000 brake horsepower in a single cylinder.

The American company, from their own experience and with the information received from Switzerland, is giving special attention to the two stroke type of Diesel engine, both for marine and stationary purposes, though they build four stroke engines and recommend them for certain purposes.

At the time when Diesel proposed his engine the engineering, metallurgical and industrial conditions enabled him to proceed directly and rapidly to its development. There were problems enough in consequence of the high pressures and temperatures experienced in the cylinder of his engine; these problems even now are not completely solved for large engines, even though the engineering geniuses of many countries have wrestled with them for a quarter of a century. Dr. Diesel was very optimistic concerning the ultimate development of his engine, and in conversation with the writer expressed a positive opinion that the problems remaining were engineering problems rather than thermal problems; the writer ventures the

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opinion that the thermal problems, not yet completely solved, are the more obstinate.

TWO VERSUS FOUR CYCLE ENGINES

The opinion just stated gives intense interest to the matter of types; whether the Diesel engine shall be two stroke or four stroke. The two stroke engine, which has its own difficulties, has the great advantage of using one working stroke for each revolution of the crank. Could it take full advantage of this circumstance, the engine could develop twice the horsepower per cylinder possible

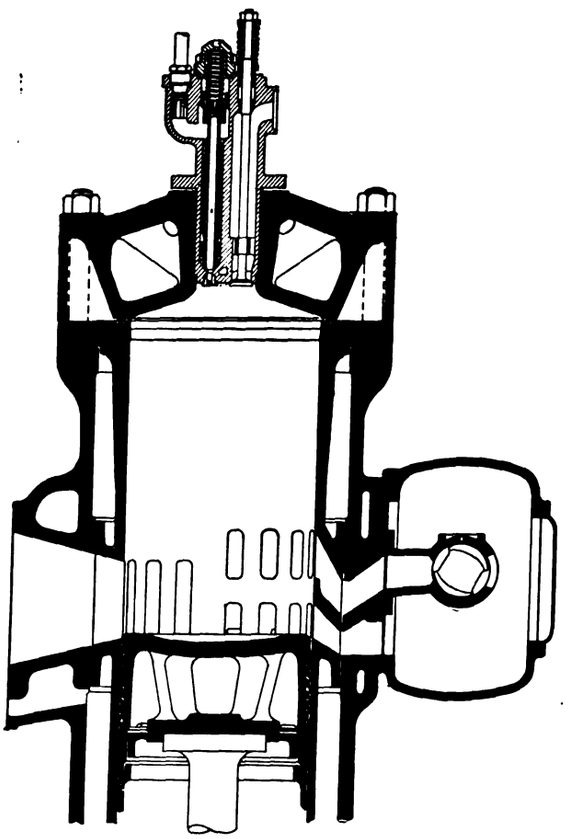

Fig. 2.—Cylinder Showing Sulzer Two-Cycle Scavenging System

with the four stroke type. Though the two stroke engine may come short of realizing such a gain, it has a great interest for marine engineers who appreciate the advantages of saving weight and space on shipboard.

Dr. Diesel found the gas engine working on the four stroke cycle well established, and naturally accepted it for his first designs. It is fair to say that that type has maintained its predominance, as the vast majority of all internal combustion engines are four stroke to this day.

TWO CYCLE GAS ENGINE

About 1880, Mr. Dugal Clerk undertook the production of a two stroke gas engine. In his book (now a classic) on the gas engine he admits that the problem became the more serious as he advanced. Mr. Clerk, a profound student and an experienced engineer, succeeded in making a two stroke engine which under laboratory test gave as good an efficiency as the four stroke engines of the same size then in use; in fact, he succeeded in showing a slight advantage when running the engine himself for laboratory tests. He could show reason why the two stroke engines should be more efficient; all two stroke proponents to the present day can also show reason. The writer leans toward conviction when reading their arguments and can see no reason why the two stroke Diesel engine, as built by the Busch-Sulzer Brothers Diesel Engine Company, cannot show at least as good economy as a four stroke engine.

It is worth while considering Mr. Clerk's engine, because all two stroke engines use his methods and because the reason for his failure is evident. In the first place he exhausted his engines through ports in the cylinder which were uncovered near the end of the working stroke. In the second place he slightly compressed the new charge (to five or ten pounds) and used it to push on the spent gases. He compressed the new charge in a separate cylinder with crank and connecting rod, giving the crank a little angular advance. He carefully shaped the cylinder head so that the new charge might advance unbroken and sweep out the spent gases just before the piston closed the exhaust ports for the compression stroke. The problem was to sweep out the spent gases without wasting the new charge. Mr. Clerk must have come pretty near doing this in his own tests. In practice fresh gas was wasted and spent gas remained behind. The failure of the two stroke gas engine was due to the necessity of compressing the mixed charge of air and fuel. Some gas engineers may object to one dictum, for many small gas and gasoline engines are working on the two stroke cycle, and also many large gas engines that use blast furnace gas or other low grade fuel. The company whose engines are under discussion concede an advantage of six or eight percent in fuel economy to the four stroke Diesel engines over their two stroke engines under shop test. They claim that in practice the margin is smaller and that commercially the two stroke engine has the advantage because it can use cheaper and impure oils and because it calls for less overhaul and repair.

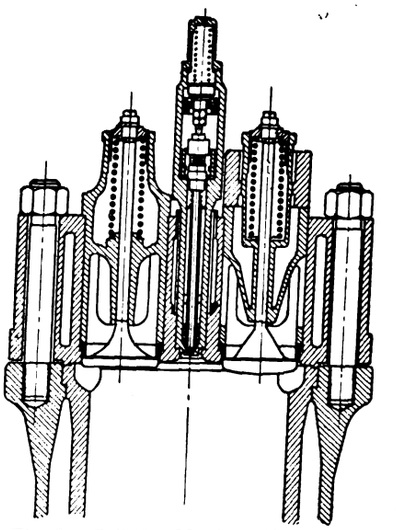

Fig. 3.—Cylinder Head of Four-Cycle Construction

CYLINDER HEAD

The two features that give the Busch Sulzer Diesel two stroke engine advantage over others of the same type are (1) the simplicity of the cylinder head, and (2) the method of scavenging.

Fig. 2 enables us to understand both of these features. The cylinder head is a simple hollow casting which expands symmetrically with the rise of temperature and which is easily water-cooled. Contrast it with the cylinder head of a four stroke engine as shown by Fig. 3. Here are shown the supply and exhaust valves and also the fuel valve for a four stroke engine, but the starting valve (not in the same plane) is not shown. Now many two stroke engines have the scavenging valves in the cylinder head and are in much the same condition, especially if the scavenging valves are duplicated to avoid large size. We remember that the scavenging valves pass the air

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under low pressure of not more than five to ten pounds.

The Busch-Sulzer engine has only two valves in the cylinder head—the little fuel valve and a small starting valve, and the latter is closed in service. Both are in a single casting which can be easily removed for overhauling.

Scavenging System

As for the Sulzer scavenging system, we see in Fig. 2 that the exhaust ports are in the left side of the cylinder and are shown uncovered by the piston. They have a generous area, but, since the pressure of the gases at release is forty pounds, there is no trouble about the exit of the spent gases. The scavenging ports are in two tiers; the upper tier of ports receives air through a rotating valve, the lower open directly into the cylinder. This is

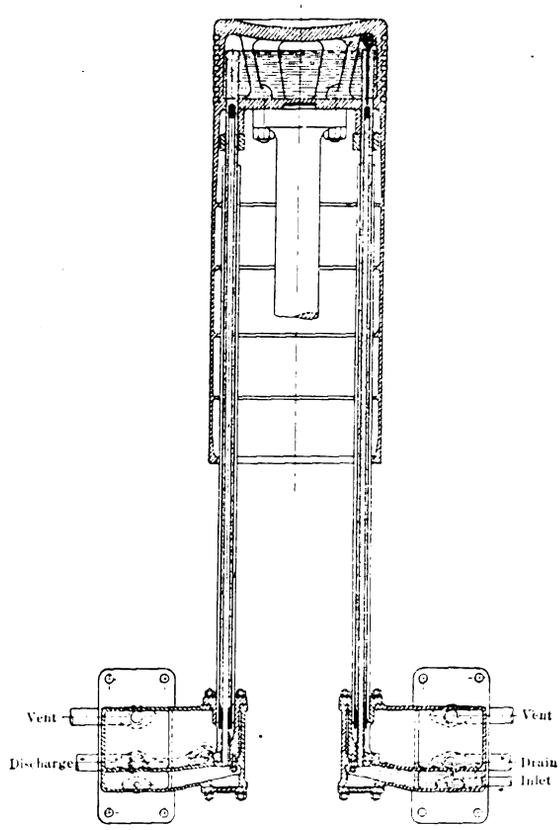

Fig. 4.—Busch-Sulzer Piston Cooling

what happens on the down stroke as the piston approaches release: (1) the piston opens the upper tier of scavenging ports, but nothing happens because the rotating valve is then shut and the scavenging air chest is protected against the release pressure of the gases; (2) the piston opens the exhaust ports on the left and they stay open till the piston closes them on the upstroke; (3) the piston, just before the end of the stroke, opens the lower tier of scavenging ports and fresh air blows across and out of the cylinder; (4) about this time the rotating valve opens and air blows up into the cylinder and cleans out the spent gases; (5) on the upstroke the piston closes the lower tier of scavenging ports, then the exhaust ports and finally the upper tier of scavenging ports, which latter supply a charge of fresh, cool air for compression.

It is claimed that analysis shows only 3 percent of spent gas in the compression charge. Since the engine always and preferably works with air in excess, the only effect of a trace of spent gases is to slightly raise the temperature during compression, and again such a slight rise of temperature will merely reduce slightly the required pressure for ignition of the fuel. The question naturally occurs, why should the two stroke engine have to concede anything to the four stroke engine in economy?

The free exhaust through the ports in the side of the cylinder enables the two stroke engine to burn all kinds of low grade fuel, as there are no exhaust valves to be gummed up by asphaltum or destroyed by sulphur. This is a matter of double importance for marine engines, since ships must take such oil as they can get in remote quarters of the world.

Cylinder Cooling

A little internal combustion engine, especially if it works most of the time at reduced load, or even inter-

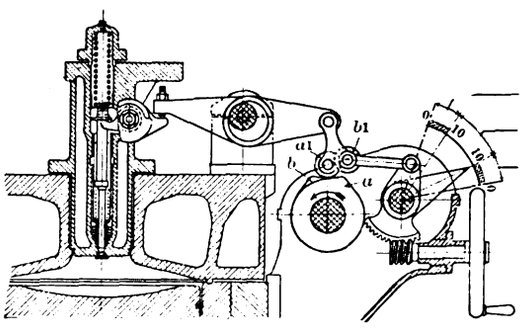

Fig. 5.—Diagram of Reversing Mechanism and Fuel Control

ruptedly, can get along almost any way; such are motorcycle engines. Some light automobiles are air cooled, but powerful automobile engines are water cooled on the heads and barrels of the cylinder. Large engines must be thoroughly water cooled, pistons as well as cylinders; and, further, it is advisable, if not necessary, to use forced lubrication of the bearings and in some cases to cool the oil. The difficulty of cooling an internal combustion engine increases with the size in geometric ratio. As the thickness of the cylinder walls must increase with the diameter and the rate of flow of heat decrease with the cylinder volume, that is, with the cube of the diameter, the difficulty will increase in proportion with the fourth power, while the area of the surface increases only with the square. Consequently the difficulty of cooling increases with the square of the diameter of the cylinder; that is to say, it is four times as troublesome to cool a 200-horsepower engine as a 100-horsepower engine, for with constant piston speed and mean effective pressure the power increases with the square of the diameter. Another way of looking at the matter is that with the same efficiency of cooling the inside of the cylinder will be hotter for the larger engine. This comes from the fact that a greater difference of temperature is required to force the heat through thicker walls. We must not be surprised that there is a tendency to reduce piston speed and mean effective pressure for large engines.

Piston Cooling

Whether or not the reader accepts the reasoning just given, he will readily agree that the water cooling of an engine is most interesting. We have already seen that the cylinder head is symmetrical and easily cooled. A glance at Fig. 2 will show that the cylinder barrel and liner can be cooled effectively and that the piston proper resembles the cylinder head in being symmetrical and well arranged for cooling; Fig. 4 will show how the water is supplied to the piston. It may be seen in the last figure that the water is supplied at the right to a long stationary pipe that reaches up into the piston and squirts water into

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it under pressure; the piston is shown only partially filled. Telescopic pipes allow the water to flow away without entering the crank case. Stuffing boxes and swinging joints are avoided.

THE PISTON

The piston proper is only long enough to carry the packing rings. Below it is an extension or skirt that covers the exhaust and scavenging ports when the piston is raised. This extension is thin and does not need to be water cooled. The piston is flanged onto the piston rod and the latter is forked at the lower end to take the connecting rod. The use of a crosshead will meet with the approval of all engineers and especially marine engineers. The connecting rod is of the marine type, adjustments of bearings being made by shims. An advantage of the two stroke cycle is that there is always a downward pressure on the connecting rod because the pressure of the gas at the top of the stroke is always more than enough to take care of the inertia forces.

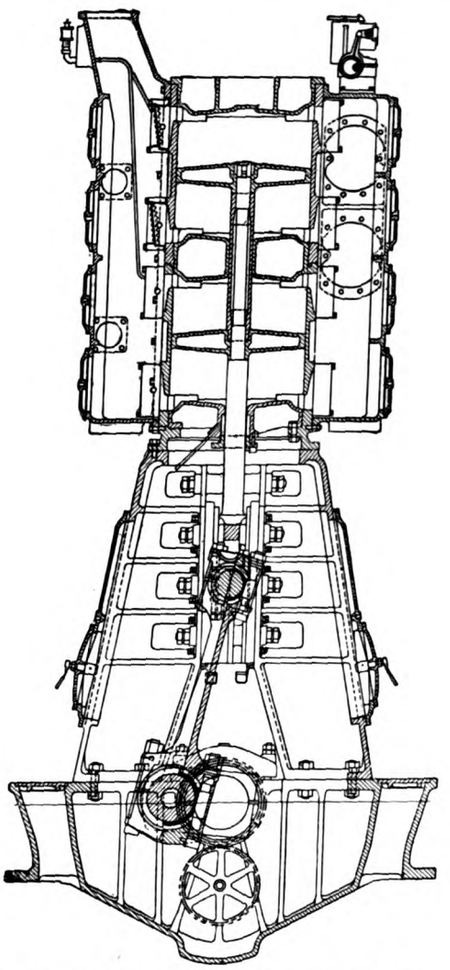

Fig. 6.—Cross Section Through Scavenging Pump, Busch-Sulzer Two-Cycle Diesel Engine

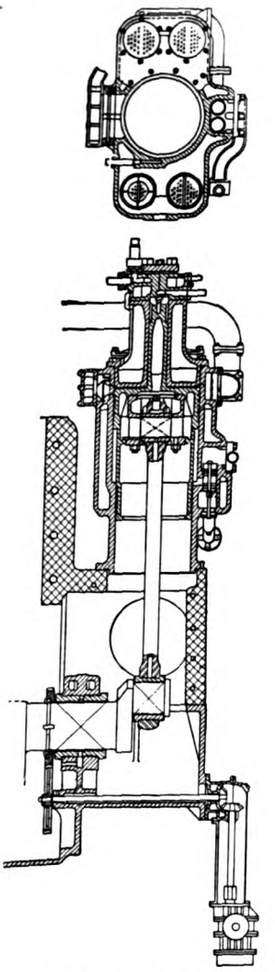

Fig. 8.—Cross Section Through Compressor

THE VALVE GEAR

Since both exhaust and scavenging take place through ports in the cylinder walls, and since the starting valve is shut when the engine is running, the valve gear is simple and light because it handles only the fuel valve. The advantage of this arrangement is most evident in the arrangement of the reversing gear for the marine engine which is shown by Fig. 5, where *a* is the cam for forward motion acting on the roller *a*; the cam *b* for backing is by the side of cam *a*, out of gear as shown in the figure. To back the engine, the hand wheel is turned until the roller *a* is lifted out of action and the roller *b* is brought into gear. Of course, all of the gears can be changed for the several cylinders of the engine by extending the reverse shaft for that purpose.

The stationary engine is controlled by a governor which determines the seating point of the suction valve of the fuel pump, each cylinder having its own pump. There is also an emergency governor that cuts off the fuel supply if the engine starts to run away. Marine engines have a governor of the latter type to prevent racing.

Fig. 7.—Shutter Valve

SCAVENGING PUMP AND AIR COMPRESSOR

The scavenging pump and the air compressor are usually driven directly from the main shaft. The crank for the scavenging pump is similar to those for the working cylinders. The air compressor is driven from a short overhung crank at the end of the shaft. The scavenger pump is shown by Fig. 6; it has two pistons tandem on the same rod, both being double acting. Having in mind that the scavenging pump handles a large volume of air at low pressure, the advantage will be recognized of using shutter valves as shown by Fig. 7.

In a submarine there is a turbo-blower for supplying the scavenging air. The blower is driven by an electric motor, the current coming from a separate generating set with its own engine. Such a drive for scavenging appears to be advisable on all ships, especially if electricity is used for driving auxiliaries, deck windlasses and winches. The air compressor has three stages with intercooler and an after cooler, as shown by Fig. 8. At the middle of the compressor is the low pressure piston actuated by crank and connecting rod. Below the piston is a trunk that works the second stage, and above is a plunger for the third stage, making a very compact arrangement.

All bearings and gears are lubricated by a forced circulation of cooled oil.

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Various reasons why the two stroke Diesel engine has advantages for marine propulsion have been pointed out incidentally, such as reduction in size, weight and cost as compared with four stroke engines, and also the ability to burn low grade and impure oils, the latter offsetting to a large extent whatever advantage the four stroke engine may have in economy. There remains the great advantage of one working stroke for each revolution of each crank.

Advantages of Two-Cycle Engine

Steamship practice has settled on the three cylinder triple engine as the standard, and that engine is a particularly sweet engine to run and has long been a favorite with marine engineers. Four crank engines have been built for large steamers, but they are accepted rather than desired. And yet the two crank compound engine gives satisfactory service and a fairly smooth turning moment. The four cylinder two stroke engine is the equal of the two crank steam engine and is to be recommended for ships that can get power enough from one or two such engines. They will handle easily and run satisfactorily. Where more power is needed, the six cylinder engine may be preferred. For light high speed engines six cylinders will be advantageous if, indeed, they are not necessary. Such an engine, if its base is rigid enough, will be perfectly balanced for all inertia forces and moments. The cranks should be balanced individually by counterweights to avoid slight springing of the shaft. Such slight springing does not hurt the shaft, but it increases bearing friction and wears out the bearings.

Comparison of Sizes and Weights

In the comparison of two and four stroke engines it is usual to point out that the former can be smaller, lighter and cheaper and let it go at that. Now there is a strong tendency to run all internal combustion engines, and especially to run Diesel engines faster than equivalent steam engines. The reason is that the entire propelling machinery (i. e., the engines themselves) is reduced in size and weight. A steamship has commonly more weight in the boilers than in the engines, and it is the latter only that gain advantage from running faster.

Propeller Efficiency

The consequence of the high speed of revolution of internal combustion engines is the necessity of using smaller propellers with less pitch ratio and higher percentage of slip. The loss of propeller efficiency from this source is likely to be 8 or 10 percent. It is therefore urged that engineers who use two stroke Diesel engines on shipboard, instead of trying only to save space and weight, consider the advantage of a slower speed of revolution and get a better propeller efficiency, thus offsetting the margin of better efficiency claimed for the four stroke engine.

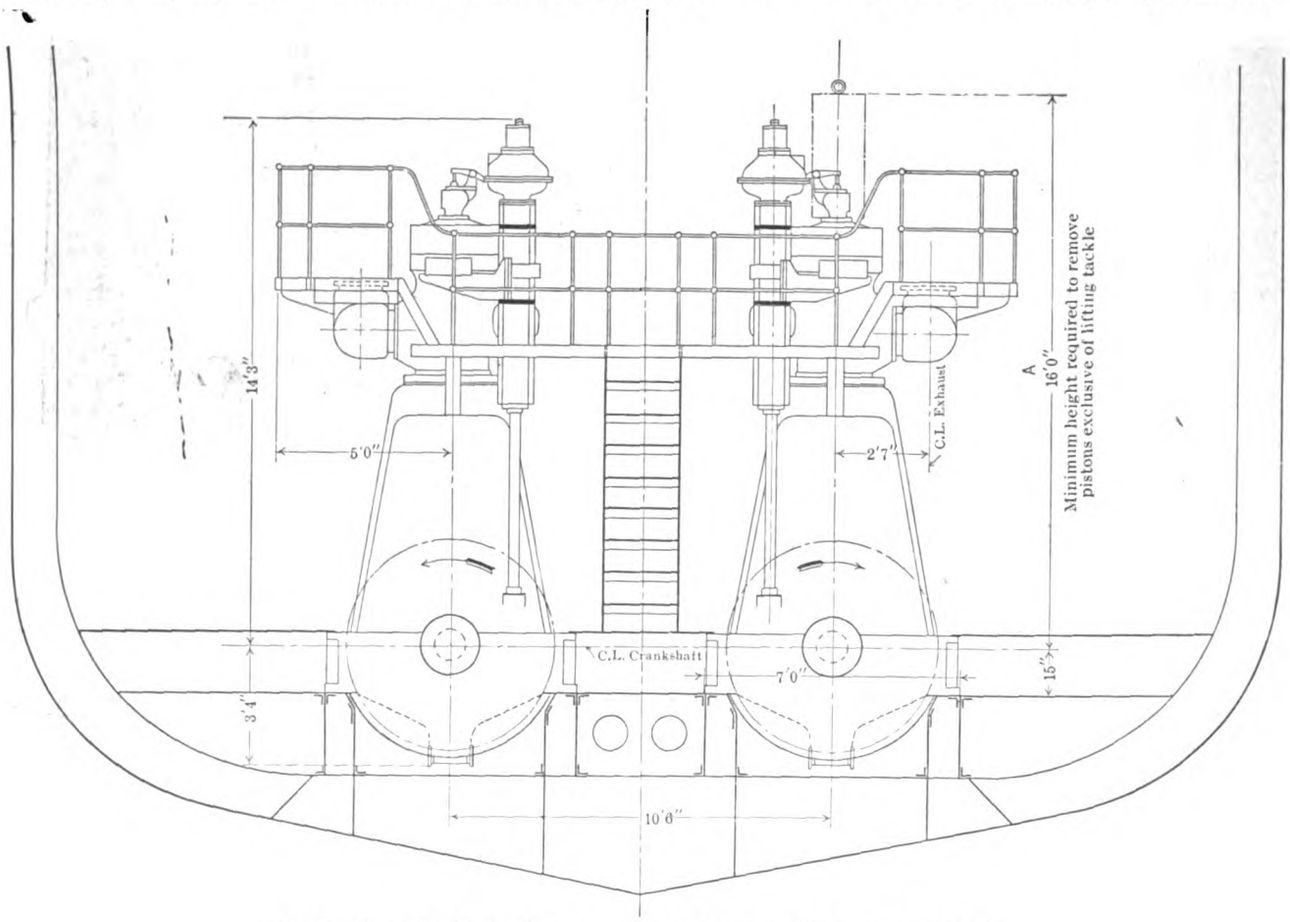

Fig. 9.—Two 650 Shaft Horsepower Busch-Sulzer Two-Cycle Marine Diesels

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Superheated Steam and Reciprocating Engines.—That the economy of coal when using superheated steam with reciprocating engines is considerable is indicated by some figures recently given regarding two twin screw vessels of nearly the same size, fitted with quadruple expansion engines and similar boilers, saturated steam being used on one vessel and superheated steam on the other. It was found, as a result of voyages extending over four years, that there was a saving of coal of seven to eight tons per day with the vessel using superheated steam, representing an economy of over 10 percent.—*Shipbuilding and Shipping Record.*

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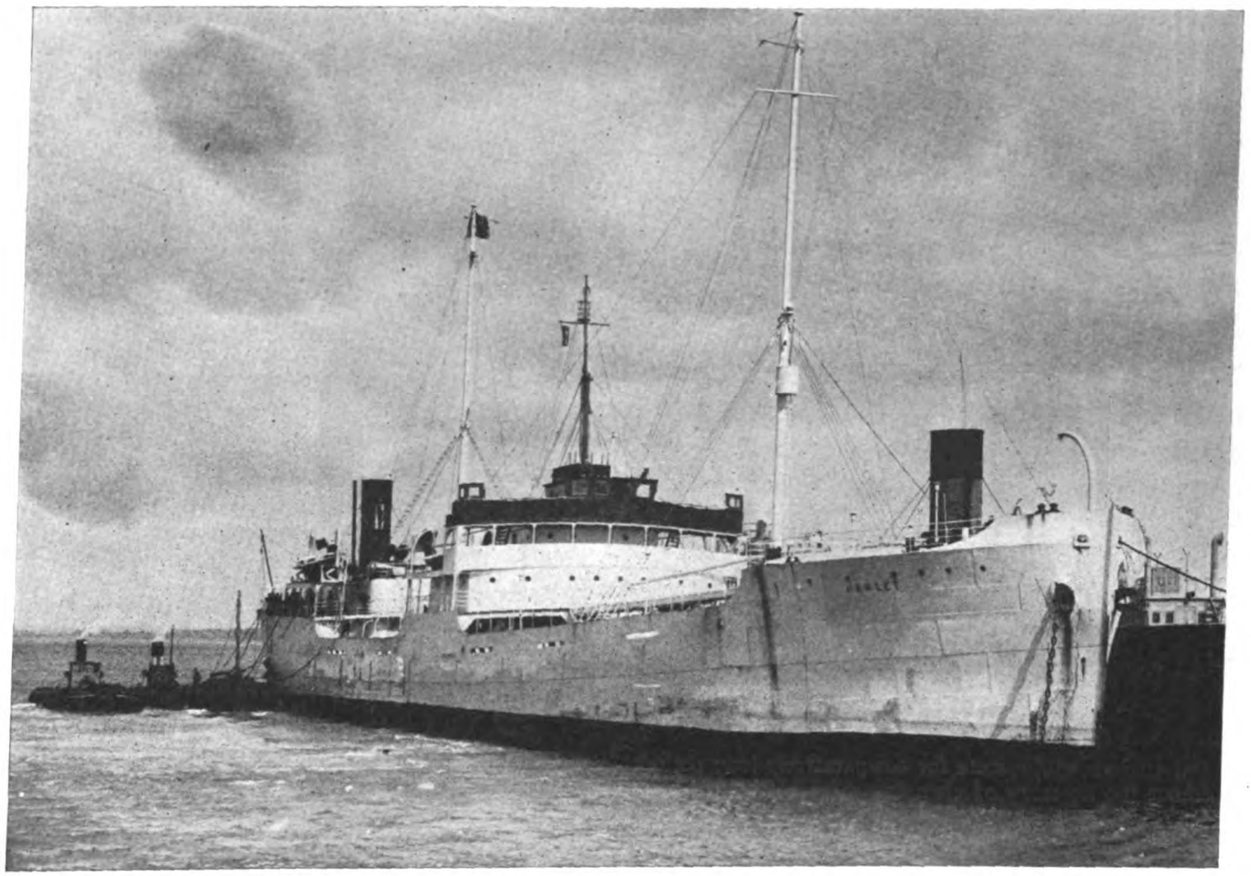

The Norwegian Motor Oil Tanker *Hamlet* Fitted With Two Polar Diesel Two-Cycle Engines

Motorships Being Standardized in Europe

Vessels Nearing Completion in Denmark and Sweden of Standard Types—Duplicates Ordered—Germany Preparing to Develop Motorship Industry

BY OUR SPECIAL LONDON CORRESPONDENT

DURING the past month two large motorships have been put into commission, one built in Denmark and one in Sweden, while another 14,000 tonner has been launched in Great Britain. It is anticipated that within the course of the next few weeks not less than half a dozen large new vessels will be completed, including the first 14,000-ton Glen motor liner *Glenogle,* fitted with 6,400-horsepower machinery. This steady increase in the European motorship fleet shows that the progress of the marine internal combustion engine is being steadily maintained, one of the most interesting features being the development of the idea of the production of standard vessels. For instance, one of the new ships mentioned above, the *Elmaren,* built by the Gothenburg Shipbuilding Company at Gothenburg, is a sister vessel to two vessels, the *Bullaren* and *Tisnaren,* which have been in commission for about a year and eighteen months respectively, and have proved extremely economical and reliable craft. So successful have they been that the owners, the Transatlantic Company of Gothenburg, have now placed orders for six exactly similar vessels, all of them to trade between Scandinavia and Sweden to America.

The *Elmaren* carries 9,400 tons deadweight with a length of 436 feet, a beam of 56 feet and a depth of 30 feet, the draft being 26 feet 9 inches. These figures should be of interest to prospective builders and owners of motorships in America anxious to decide upon a standard craft of improved design. The Transatlantic Company has adopted the modern idea of giving their cargo boats relatively high speed, and they are all capable of maintaining twelve knots at sea. In order to attain this speed, two 2,000 indicated horsepower, six cylinder engines are installed with a cylinder diameter of 740 millimeters and a stroke of 1,100 millimeters. They are of the ordinary Burmeister and Wain design built under license by the Gothenburg firm and embody all the latest improvements which have been effected at Copenhagen.

On these engines a three stage air compressor is fitted, this being now commonly adopted for the Burmeister and Wain engines instead of the original arrangement of having only the high pressure stage directly coupled to the main motor. Water is now employed for cooling the pistons instead of oil, which was originally used, as it was found that this tended to carbonize within the piston and cause inefficient cooling. Some improvements have also been made in the exhaust valves, with the result that the

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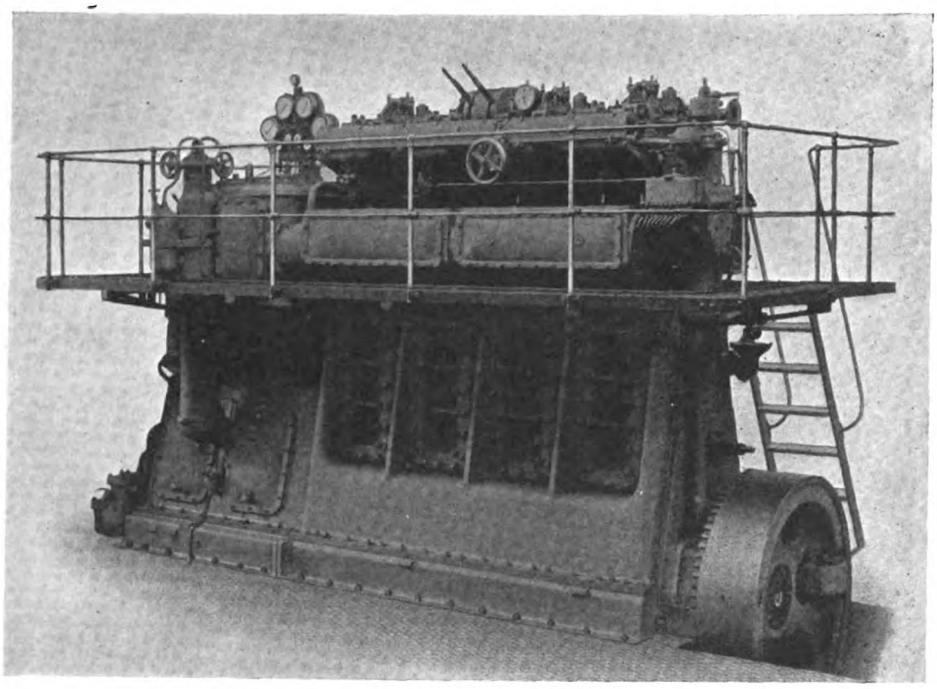

A 420-Horsepower Sulzer Marine Two-Cycle Diesel Engine

latest engines will operate for comparatively long periods without the necessity of changing these valves.

THE MOTORSHIP THEODORE ROOSEVELT

The second vessel just completed is the *Theodore Roosevelt*, constructed by Burmeister and Wain for Mr. Fred Olsen, of Christiania, the first of five similar vessels to trade between Scandinavia and the Pacific Coast of America through the Panama Canal. It is considered among Scandinavian shipowners that this route offers one of the best opportunities for the motorship—first, because it is a long trip and motor vessels show to special advantage on such routes, and, secondly, because oil can be obtained relatively cheaply on the Pacific Coast. The writer uses the word "relatively" advisedly, since liquid fuel in Europe is now costing anything up to £13 or £14 per ton, so that even the high price at Pacific Coast ports seems to European owners relatively cheap. It must, however, be remembered that coal in Europe costs from £5 per ton in London to about £12 per ton at Gothenburg, so that the motorship still shows an enormous advantage.

The *Theodore Roosevelt* carries approximately the same amount of cargo as the *Elmaren*, but is a slower boat, being equipped with two 1,550 indicated horsepower engines of the Burmeister and Wain type, instead of 2,000 horsepower as in the *Elmaren*. These give a speed of approximately 11 knots at sea, while the ship has a fuel consumption of only about 10 or 11 tons per day including all the auxiliary machinery. Needless to say, this is electrically driven, as practically every new motor vessel now built in Europe is equipped with electrical auxiliary plant.

14,000-TON, 14-KNOT MOTORSHIPS

The 14,000-ton vessel just launched on the Clyde for the Glen Line is the second of its class and the first will start on her maiden voyage in the course of a few weeks. These ships, of which two more are to be built, are exciting exceptional interest, not only owing to their size, but also to their speed, which is between 13½ and 14 knots—an unheard-of figure for the average cargo vessel. It is, however, but another indication of the European shipowner's impression that higher speed is needed for cargo craft, and the motorship offers particular opportunities in this direction, since it can be run at three-quarter speed with comparatively little loss of efficiency.

The 14,000-ton ships are provided with a couple of 3,200 indicated horsepower engines, the speed on trials being over 14 knots when loaded. They carry about 20 passengers, and no effort has been spared to render them most efficient in the matter of handling cargo, the electric winches being especially powerful and numerous. This has involved the installation of three 400-horsepower Diesel driven electric generating sets, so that the total power of oil engines installed in the vessels is somewhere in the neighborhood of 7,600 horsepower.

The main engines are of the eight cylinder type with cylinders 740 millimeters by 1,150 millimeters and operate at 115 revolutions per minute. Both engines are fitted with two high pressure air compressors of the three stage type, each being sufficient to maintain the necessary supply of air in the event of failure of one. This precaution has been adopted owing to the fact that the greatest trouble experienced with Diesel engines during the past few years has been in connection with air compressors. It seems a matter of some difficulty to design a completely effective type, and troubles with valves have been fairly numerous.

GERMANY AND MOTORSHIPS

It is reported that shipowners and shipbuilders in Germany are making preparations to develop motorship building as soon as conditions become propitious, and it is stated that a combination of the A. E. G. and the Hamburg-American Line, which was suggested during the war, will shortly come into operation and a big shipyard and works at Hamburg will be devoted entirely to the construction of standard motor vessels. The engines will be of the opposed piston two cycle type, such as the A. E. G. was building before the war for stationary purposes on a large scale, although the majority of motors constructed were of low power. It is believed that a series of 8,000 ton craft fitted with 2,000-horsepower machinery will be built, and although a good deal of secrecy is maintained over this venture, there is little doubt that it will be carried out in the near future. In the meantime, two orders have been placed with Blohm and Voss for motorships for German shipowners, while the conversion of an existing steamer to motor power is now being made in Hamburg.

How an Engineer Got Rich

We have just learned of an engineer who started poor twenty years ago and has retired with the comfortable fortune of $50,000. This money was acquired through industry, economy, conscientious efforts to give full value, indomitable perseverence and the death of an uncle who left the engineer $49.999.50.—*Official Bulletin, Colorado Society of Engineers.*

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Cargo Motorships vs. Steamships

Comparative Calculations of the Expenses and Earnings for the Operation of Steam and Motor Ships

BY CHARLES E. LUCKE*

CARGO motorships in overseas service have been steadily increasing in numbers for several years, and at an increasing rate, and this fact alone is proof of successful competition with steamers. The performance of these freighters has established beyond question the very superior fuel economy of the internal combustion over the steam type of propelling machinery, without any loss whatever in reliability when the oil engines are of good modern design. For all ocean freight service motorships must now be considered in commercial competition with steamships on quite the same terms as one type of steam freighter with another. The competition for a given size and speed of ship is reduced to a comparison of freight earnings, typical of one class of propelling machinery with reference to another. Earnings are measured by cargo capacity and freight rates on the one hand and on the other by operating costs per trip or per mile.

1. Method of Treatment

Comparing cargo capacities of two vessels of equal size and speed, but with different machinery, a difference in capacity is found for steam vessels, as in the case of steam turbines compared with reciprocating engines. The geared turbine invariably permits of greater cargo capacity both for deadweight cargo and measurement cargo (more or less than forty cubic feet per ton), but the amount of the difference naturally depends on the design of the reciprocating engines, the turbines, the boilers and the auxiliary machinery. The situation is quite the same in nature when the cargo capacity of motorships as a class is compared with that of steamships as a class, and while in this case the motorship usually permits of greater cargo capacity than steamships, the amount of the difference depends on the design of the machinery being compared.

Comparative Cargo Capacities

General figures of comparative cargo capacities of motorships as a class, with reference to steamships as a class, are useful for preliminary estimates but are not at all satisfactory or conclusive in a final analysis of the probable earnings of a given ship over a selected trade route. Commercial conclusions can be based only on careful calculations with actual or estimated values for each of the items entering into the total. This requires an analysis of the total deadweight† of the ship and the evaluation of all of the items, except cargo. The cargo weight is determined by subtracting the sum of these items from the total deadweight capacity of the ship. These deadweight items include the weights of (a) machinery; (b) fuel in bunkers; (c) water; (d) crew and effects; (e) stores, including food and spare gear. For comparative estimates it is sufficient to evaluate only those items that differ by a constant weight, as, for example, machinery weights for motorship over steamship, and minor items such as crew and effects may be ignored entirely, because difference between them in comparing two ships is of no consequence.

Fuel Capacity

To evaluate the weight of fuel to be carried in bunkers requires a definite assumption of the length of voyage, and a decision as to where and when refueling is to be done, in addition to fixing the fuel consumption per day at sea and in port. It is clear that a ship carrying fuel for a round trip on a long voyage will have less cargo capacity outbound than returning, and the difference will be equalized only if bunkers are filled at each end. The most complicated case is that in which the ship makes a stop at many ports and fills bunkers at all, or at a few of them. These are matters of ship operating management rather than type of machinery, but with the widely differing fuel consumptions per day for motorship vs. steamship, the question of relative suitability of one or the other for a given trade route at once arises, and the route factor may become the deciding one. In general, a long route with fuel in bunkers for the round trip is the condition most favorable to the motorship as a cargo carrier.

Operating Expenses

Comparative figures on ship operating expenses per day, per voyage or per year for two or more ships differing only in their machinery are not only quite as necessary as the comparison of their cargo capacities, for a conclusion as to the commercial merits of one over the other, but much more important. When motorships are compared with steamships on this expense basis, much greater differences are found than in the matter of cargo capacity, and these expense differences are always very much in favor of the motorship if fixed or investment charges are ignored. They are also in favor of the motorship even when including the fixed charges if the vessel is worked hard enough, that is, kept at sea instead of being held in port.

Fixed Charges

Fixed or investment charges are annual constant expenses and their value per mile or per voyage naturally is less as the miles per voyage or per year made by the vessel is greater. Motorship machinery always costs more than steamship machinery per horsepower, therefore investment charges against operation are always against the motorship. The importance of this item in the list of expenses becomes less as the operating expenses for labor and consumable supplies become larger, and the more the ship is worked the more the cost of consumed supplies, including fuel, controls the total. This operating expense is always in favor of the motorship, mainly because of its very low fuel consumption, so it is clear that whether the total cost of operating the ship (made up of fixed charges and operating expenses) will always favor the motorship or not will depend on the relative size of the two items—one always in favor and the other always against the motorship, the former and favorable item being larger and the latter unfavorable item smaller, as the ship is kept at sea the more days per year. To reach a decision on these

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† The term deadweight as used herein includes the machinery. Strictly speaking, the deadweight only covers portable objects as cargo, fuel, water, stores, crew and passengers.

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costs, it is necessary to prepare an itemized statement and calculate or estimate the value of each item, including: (a) interest on investment; (b) depreciation, including obsolescence; (c) insurance; (d) maintenance; (e) loss and damage; (f) fuel; (g) water; (h) crew wage and subsistence; (i) stores; (j) port charges; (k) cargo handling.

Fluctuating Values

Values of these items can be determined only on the basis of assumptions of certain prices, which, like all market prices, are subject to wide fluctuation in any one place from time to time and considerable differences in different parts of the world. A leading example of this condition is fuel price, concerning which the only thing that seems to be sure is a general upward trend everywhere, judging from past figures. Crew wages and food costs entering into subsistence are likewise unstable, but not so widely as fuel prices. Consideration of such items must, therefore, involve a good deal of opinion and judgment, and appreciable differences in conclusions may well follow the use of maximum prices or wages in one calculation and minimum figures in another. However this may be, it is a fact that the quantities of these items to which the prices apply always favor the motorship. It necessarily follows, therefore, that *high prices of items of running expense make total operating costs more favorable to the motorship*, a very significant conclusion in view of present price tendencies.

Determination of Fixed Charges

Evaluation of fixed charges, or items of investment expenses, are even more dependent on opinion than prices of supplies or wages of labor, because these are largely fixed by the system of accounting used. Accountants differ widely in their practices as to interest charges on capital investment reduced to equivalent per ton mile, and still wider differences are to be found in the treatment of depreciation, obsolescence and maintenance, both in finding the value of each and in the relation of depreciation to maintenance on the one hand and of obsolescence in relation to period of interest charges or to depreciation on the other. As a consequence, all estimates of total expenses of operating one ship as compared with another must necessarily involve some more or less considerable variation when made up by different estimators, due to opinions on accounting; to estimates as to proper prices of supplies and wages; to voyages to be made; to days at sea or in port per year; to refueling points, and to relative amounts of cargo of the deadweight as compared with the measurement classes; and such items, all in addition to the determinable items of an engineering nature, such as fuel consumption per hour per horsepower. These sources of variation will account for the many differences of opinion as to the relative value of one type of ship compared with another for a given service, which have always existed and always will.

In spite of all these variables, some of fact and others of opinion, entering into the estimate of the cost of operating a ship per year, or the cost of carrying freight per ton mile, the fact remains that the only estimate worth while must be based on the evaluation of individual items. It is also true that for all reasonable values of these items in comparing motorships with steamships as cargo carriers the motorship will be found to be the most economical vessel operated on a trade route that is long enough.

To assist those interested in working out such cost comparisons some convenient forms and tables have been developed and for each item presents a brief discussion, with an estimate of a fair value for it for one size of ship. These should be useful to naval architects, marine engineers, shipbuilders, shipowners and shipping interests generally, not only for the values of the items and estimates of totals here presented, but also as a means of guiding individual new estimates when it is desired to determine the effect of a change in any one item, due to a new condition, or price, or service, or to a difference in opinion as to the proper value. The more common such cost calculations become, and the more accurately they are made, the quicker will the shipping world come to a correct understanding of the commercial value of motorships and their proper place in water-borne freight transportation. Without such calculations, the question will remain one of opinion unworthy of supporting a real business conclusion as to the value of motorships as investments.

2. Comparative Cargo Capacities of Motorship and Steamship of 10,000 Deadweight Tons

As cargo carrying capacity is to be calculated by differences between total deadweight and that of supplies carried for deadweight cargo, each of these items must be considered separately. A second calculation for measurement cargo (bales) measuring more than forty cubic feet per ton can then be made.

In this comparison the first item is weight of machinery, and after it weight of fuel for a given voyage, with other supplies and stores. This comparison is made in detail for two ships—one a steamer and the other a motorship of identical hulls and shaft horsepower. The basis of the estimates is the steamer, taken as 10,000 deadweight tons and propelled by a single screw with geared turbines and oil-fired Scotch boilers, and the usual steam auxiliaries for both engine room and deck service. This is quite generally accepted as the most economical cargo steamship. The motorship is propelled by twin screws, with two four cycle six cylinder Worthington reversible marine Diesel engines, direct coupled to the propeller shaft and having Worthington auxiliaries. These auxiliaries include Diesel electric generating sets in the engine room, generating electricity for ship lights and for operating electric motor driven pumps and compressors in the engine room, and steering gear, winches and windlass on deck.

Each ship is powered with 2,700 shaft horsepower, giving the ships each a speed of 11 knots or 264 nautical miles per day, assuming equal propeller efficiency for the twin screws of the motorship and the single screw of the steamship. Basin tests of a single propeller placed in the normal position abaft the stern post and of twin screws placed out in free water have shown that the twin propellers can work with a very much higher speed and still attain the same efficiency as the slow running single propeller. It should also be expected that the propulsive power in a seaway would be better maintained with two small deeply submerged propellers than with one large single propeller, which very likely will be lifted partly out of the water when the ship pitches.

Trials with sister ships—one with a single slow speed steam engine and another with higher speed twin screw Diesel engine installations—have been carried out both in England and in Sweden and have both shown that the twin screw arrangement is superior to the single screw, based on same shaft horsepower. In order not to complicate matters, the efficiency is here considered equal in both installations.

The Machinery Weights

The *machinery weight* of the steam installation is estimated at 550 tons and that of the Diesel installation at 630 tons, the difference, 80 tons, being in favor of the steamship. Taking the total deadweight capacity of the

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steamship to be 10,000 tons, then the question of machinery weights can be eliminated from further consideration by taking the value 9,920 tons for the motorship deadweight capacity.

The cargo capacity deadweight will be 10,000 tons for the steamer, or 9,920 for the motorship, less the sum of the weights of bunker fuel, water and stores for each ship, and the numerical value of these items must be separately determined.

STORES

Stores for deck, engine and steward's department are estimated at about one ton per day for each ship, and while considerable variation in this figure is possible, even the largest reasonable value is so small a part of the total deadweight that it is hardly worth discussing.

FRESH WATER

Fresh water is required on both vessels for drinking and washing, the amount required being, at an outside figure, about twenty gallons per man per day with little or no reserve. Assuming a crew of about forty men all told, the nearest round number is three tons per day for each ship. In addition, the steamship will require some make-up water to equalize losses, and this is estimated at ten tons per day, or about 2 percent of the boiler evaporation, to be carried in tanks. The total water for the motorship depends on the number of days for which water must be carried, while for the steamship the number of days at sea determines the total make-up water. This factor of days at sea vs. days in port per voyage or per year also enters into the total items and is worth some study.

Sea days, in relation to *lay days*, depend on the length of the voyage, the speed of the vessel at sea and the estimated time of lading, unloading or waiting for cargo while lying in port. These same factors determine the total time of a round trip or turnaround, and the number of voyages per year. While almost any figure might be assigned to *lay days* as a matter of opinion, it is clear that whatever value be chosen, the ratio of *sea days* or *steam days* to the former will be greater the longer the voyage. The accompanying tables indicate this clearly, the first one being for the speed of the ship under consideration, the second for a faster vessel and different conditions.

TABLE 1.—SCHEDULE FOR 11-KNOT VESSEL

Voyage	Days: Lay	Days: Steam	Turnaround: Days	Turnaround: Miles	Voyages per Year (10 Days Overhaul)
New York to	10				
Liverpool to	21	12.5			
New York	11	12.5			
6,439 miles	42	25.0	67	6,439	5.3
New York to	10				
Buenos Aires to	21	22.5			
New York	11	22.5			
11,740 miles	42	45.0	87	11,740	4.1
New York to	11				
South Africa to	21	30.5			
New York	11	30.5			
16,000 miles	43	61.0	104	16,000	3.4

TABLE 2.—SCHEDULE FOR 12-KNOT VESSEL

Voyage	Days: Lay	Days: Steam	Turnaround: Days	Turnaround: Miles	Voyages per Year (25 Days Overhaul)
New York to	6				
Liverpool to	11	11.5			
New York	7	11.5			
	24	23	47	6,439	7.23
New York to Cape Town	10				
Cape Town to	4½	32			
Algoa Bay to	4½	2			
E. London to	4½	1			
Port Natal to	4½	1			
Cape Town to	4	3			
New York	11	33			
	43	73	116	15,228	2.93
New York to	10				
Panama to	1	9			
Yokohama to	3½	27			
Kobe to	4	1½			
Shanghai to	5½	3			
Hong Kong to	7	3			
San Francisco to	1	13			
Panama to	1	24½			
New York	11	9			
	44	90	134	23,291	2.54

From the figures of the schedule of Table 1, the total weights of water to be carried in tanks for each of the three typical voyages are stated in Table 3.

TABLE 3.—WEIGHT OF WATER IN TANKS—LONG TONS

Voyage	Item	Steamship: Out	Steamship: In	Motorship: Out	Motorship: In
New York to Liverpool and return	Water per day.	13	13	3	3
	Days' supply...	12.5	12.5	12.5	12.5
	Total required..	162.5	162.5	37.5	37.5
	Reserve	12.5	12.5	2.5	2.5
	Total in tanks..	175.	175.	40.	40.
New York to Buenos Aires and return	Water per day.	13	13	3	3
	Days' supply...	22.5	22.5	22.5	22.5
	Total required..	292.5	292.5	67.5	67.5
	Reserve	32.5	32.5	7.5	7.5
	Total in tanks..	325.	325.	75.	75.
New York to South Africa and return	Water per day.	13	13	3	3
	Days' supply...	30.5	30.5	30.5	30.5
	Total required..	396.5	396.5	91.5	91.5
	Reserve	43.5	43.5	8.5	8.5
	Total in tanks..	440.	440.	100.	100.

FUEL

Fuel is the most important of the deadweight items, not only because it is the largest, but also because in it are found the largest differences between steamships and motorships. As it is assumed that the steamship will burn fuel oil and that both ships will have double bottom tanks, the comparison can be made directly. The weight required must be calculated from the fuel consumption of the main engines and auxiliary machinery at sea and that of the auxiliaries in port, and the bunker or tank capacity for a given voyage or radius of action for given bunkers and tanks from the density of the fuel oil of different grades obtainable.

While any oil may be classed as fuel oil, it is common practice to regard oil at or near 16 degrees Baume as low grade and suitable for boilers, and oil at or near 22 degrees Baume as high grade and suitable for internal combustion engines. The lighter oils with large Baume numbers usually bring higher prices because of the greater ease in handling them, due to greater fluidity and freedom from dirt. Therefore, while Diesel engines can use any oil that can pass through the pumps, it is considered worth while to pay a little more for the lighter, cleaner, more fluid oils, to avoid the necessity for heating the heavier viscous oil to make it flow and subsequently filtering and settling to clean it. On the other hand, with boilers, when a little heat more or less matters but little and dirt is less serious in oil, it is customary to buy a cheaper oil. However, even here there are exceptions, some engineers and owners having come to the conclusion that a little better grade of oil is worth the comparatively small increase in price.

In this comparison it is assumed that 16 degrees Baume oil will be used for the boilers and 22 degrees Baume oil for the internal combustion engines. These oils, according to Table 4, weigh 7.904 pounds and 7.677 pounds per

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United States gallon, or 335.74 and 322.43 pounds per 42-gallon barrel respectively. The former requires 6.67 barrels per long ton of 2,240 pounds and the latter 6.95 barrels.

Supplies of oil are now becoming available at an increasing number of points reached by ships throughout the world, as shown in Appendix Table 18, which gives a partial list of such fuel oil stations maintained by various oil companies.

TABLE 4.—FUEL OIL WEIGHTS

Baume	Pounds per Gallon	Pounds per Barrel (42 Gallons)	Barrels (42 Gallons) per Ton — Short (2,000 Pounds)	Barrels (42 Gallons) per Ton — Long (2,240 Pounds)
14.....	8.102	340.28	5.877	6.583
15.....	8.052	338.18	5.914	6.624
16.....	7.994	335.74	5.957	6.672
17.....	7.935	333.27	6.001	6.721
18.....	7.885	331.17	6.039	6.764
19.....	7.835	329.07	6.078	6.808
20.....	7.777	326.63	6.123	6.858
21.....	7.727	324.53	6.163	6.902
22.....	7.677	322.43	6.203	6.947
23.....	7.627	320.33	6.243	6.993
24.....	7.577	318.23	6.285	7.039
25.....	7.527	316.13	6.326	7.086
26.....	7.477	314.03	6.369	7.133
27.....	7.435	312.27	6.405	7.173
28.....	7.885	310.17	6.448	7.222
29.....	7.344	308.45	6.484	7.262
30.....	7.294	306.35	6.528	7.312

As the double bottom bunkers of the motorship can hold sufficient oil for about 20,000 miles, it is evident that this type of vessel is more independent of the location of these fuel oil stations than is the steamer.

Fuel consumption in pounds per hour per shaft horsepower can be pretty accurately predicted for main engines from data on hand, and the same is true for engine room auxiliaries, or the total for all purposes at sea. There is, however, considerable latitude in estimates of port requirements for cargo handling and general ship purposes. This is not serious, however, as the amount is small in comparison with consumption at sea, except for those cases where the ship is operated on short runs with very long port stays, a quite special case. No extraordinarily low figures obtained on trial trips, or with machinery in abnormally fine condition in the hands of builders' experts trying to make a record, can be accepted in estimates of commercial ship operation. For this purpose the fuel consumption figures must be those obtainable in every-day service with engine room crews of average quality and skill.

Fuel Consumption for Diesel Engines

The fuel consumption of a Diesel engine is a very definite figure, and so long as the exhaust is clear there is absolutely no difference in the consumption during ordinary tests in the shop, or at any time in service in the ship. The consumption in large four cycle Diesel engines is about 0.41 pound of fuel oil per shaft horsepower. To this figure has to be added the fuel consumption of the auxiliary engine generating electricity for motor driving the pumps, the separate compressors, the steering gear and for the electric lights. The power required for this service at sea is about 50 brake horsepower; the consumption in these smaller engines is about 0.44 pound per brake horsepower, whereby the total consumption of a 2,700 shaft horsepower plant will be $\frac{(2{,}700 \times 0.41) + (50 \times 0.44)}{2{,}700}$ = 0.42 pound per shaft horsepower. Adding about 7 percent for incidental losses or waste, there is obtained 0.45 pound per shaft horsepower for all purposes at sea. The total per day for all purposes at sea for the motorship is, therefore, $2{,}700 \times .45 = 1{,}215$ pounds per hour, = 29,160 pounds per day of 24 hours, $= \frac{29{,}160}{322.4} = 90$ barrels of 22 degrees Baume oil, $= \frac{29{,}160}{2{,}240} = 13$ long tons.

In port, the motorship may use one or all of its one, two or three auxiliary Diesel engine generating sets, supplying current for all purposes, including electric winches for cargo handling. A total of 2,000 brake horsepower hours per day of auxiliary engines will carry all reasonable winch loads on a 10,000-ton ship, with the ship's lighting and pump service. This is equivalent to an average of 150 brake horsepower for 10 hours for hoisting or lowering and 21 brake horsepower for 24 hours for ship service. This total power requires $2{,}000 \times .44 = 880$ pounds fuel per day = .4 long ton $= \frac{880}{322.4} = 2.7$ barrels in round numbers.

Fuel Consumption for Turbine Installation

Steam machinery fuel consumption estimates are subject to much wider variation, as they may easily differ one from another by 100 percent, due to differences in design or in condition in which the boiler and machinery is maintained. As the geared turbine is considered a highly economical equipment with high pressure superheated steam and good vacuum, it is taken as a basis of comparison. While test water rates of 12 pounds are obtained for these turbines, with boiler evaporation of 14 pounds steam per pound of oil or better and 12 percent of turbine steam or less for auxiliaries, actual ship service with present-day crews is not so good. Losses in boiler efficiency, losses in vacuum, steam for heating the viscous fuel oil and other similar items will require more fuel. A fair service water rate would be 13.6 pounds of steam per hour per shaft horsepower for the turbine and 14 percent of this or 1.9 pounds per shaft horsepower for auxiliaries, making a total of 15.5 pounds per hour per shaft horsepower. This is equal to $15.5 \times 2{,}700 = 41{,}850$ pounds of steam per hour, or about 450 long tons per day. A fair service value for evaporation is 13 pounds steam per pound of oil, so the oil consumption is $\frac{41{,}850}{13} = 3{,}220$ pounds per hour $= \frac{3{,}220}{2{,}700} = 1.2$ pounds per hour per shaft horsepower. This is equivalent to $24 \times 3{,}220 = 77{,}280$ pounds per day = 34.5 long tons per day = $34.5 \times 6.67 = 230$ barrels for 16 degrees Baume oil. This is 2.65 times the motorship requirement by weight and 2.55 times by volume.

Steamship fuel oil consumption in port is proportionately large, because steam winches have very high water rates, as is well known, and there is considerable condensation in the long steam pipes. A conservative estimate is 5 pounds of fuel oil per brake horsepower, and for the 2,000 brake horsepower hours of port service per day the oil required will be 10,000 pounds or 4.5 long tons = $4.5 \times 6.67 = 30.0$ barrels.

The fuel item of the deadweight can now be calculated for the three typical voyages, and it will be assumed that

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oil is to be carried for a round trip and with some reserve. These figures are given in Table 5 and the reserve is estimated at about one-eighth of that required for consumption outbound.

TABLE 5.—WEIGHT OF FUEL IN BUNKER TANKS—LONG TONS

Voyage	Item	Steamship Out	Steamship In	Motorship Out	Motorship In
New York to Liverpool and return 6,439 miles	Fuel per day in port..	4.5	4.5	.4	.4
	Port fuel, 42 days....	189.0	94.5	16.8	8.4
	Fuel per day at sea...	34.5	34.5	13.0	13.0
	Sea fuel, 25 days....	826.5	431.3	325.0	162.5
	Total required.....	1,051	526	342	171
	Reserve	129	129	38	38
	Total carried.....	1,180	650	380	210
New York to Buenos Aires and return 11,740 miles	Fuel per day in port..	4.5	4.5	.4	.4
	Port fuel, 42 days....	189.0	94.5	16.8	8.4
	Fuel per day at sea...	34.5	34.5	13.0	13.0
	Sea fuel, 45 days....	1,552	776	585	293
	Total required.....	1,741	871	602	301
	Reserve	219	219	78	78
	Total carried.....	1,960	1,090	680	380
New York to South Africa and return 16,000 miles	Fuel per day in port..	4.5	4.5	.4	.4
	Port fuel, 43 days....	193	97	17.2	8.6
	Fuel per day at sea...	34.5	34.5	13.0	13.0
	Sea fuel, 61 days....	2,105	1,052	793	386
	Total required.....	2,298	1,149	810	395
	Reserve	287	287	100	100
	Total carried.....	2,590	1,440	910	500

The cargo capacity deadweight is determined by subtracting from 10,000 tons the sum of each of the items of deadweight separately computed, fuel, water and stores, and these figures are collected in Table 6. It is apparent from the table that in spite of a handicap of 80 tons excess machinery weight, the motorship has in all cases a greater cargo carrying capacity than the steamship, because of its low fuel consumption. It is also clear that this difference is greater for the longer voyages by increasing margins, which again indicates the special superiority of motorship for this long voyage class of service.

Bulk cargo (measuring over 40 cubic feet per ton) conditions are also favorable to the motorship, as the following figures will show. The engine room of the motorship carrying all the machinery except deck gear is shorter than the combined engine and boiler rooms of the steamship.

(To be concluded.)

TABLE 6.—DEADWEIGHT DISTRIBUTION AND CARGO CAPACITY

Voyage	Item	Steamship Out	Steamship In	Motorship Out	Motorship In
New York to Liverpool and return 6,439 miles 42 lay days 25 sea days 67 total days	Fuel in bunkers.....	1,180	650	380	210
	Water	175	175	40	40
	Stores	70	70	70	70
	Excess machinery Weight			80	80
	Total	1,425	895	570	400
	Total deadweight capacity	10,000	10,000	10,000	10,000
	Deadweight cargo by difference	8,575	9,105	9,430	9,600
New York to Buenos Aires and return 11,740 miles 42 lay days 45 sea days 87 total days	Fuel in bunkers.....	1,960	1,090	680	380
	Water	325	325	75	75
	Stores	90	90	90	90
	Excess machinery Weight			80	80
	Total	2,375	1,505	925	625
	Total deadweight capacity	10,000	10,000	10,000	10,000
	Deadweight cargo by difference	7,625	8,495	9,075	9,375
New York to South Africa and return 16,000 miles 43 lay days 61 sea days 104 total days	Fuel in bunkers.....	2,590	1,440	910	500
	Water	440	440	100	100
	Stores	100	100	100	100
	Excess machinery Weight			80	80
	Total	3,130	1,980	1,190	780
	Total deadweight capacity	10,000	10,000	10,000	10,000
	Deadweight cargo by difference	6,870	8,020	8,810	9,220

SUMMARY

	Steamship Voyage	Steamship Year	Motorship Voyage	Motorship Year
Liverpool, 5.3 voyages per year, cargo tons	17,680	93,704	19,080	100,859
Buenos Aires, 4.1 voyages per year, cargo tons.....	16,120	66,092	18,450	75,645
South Africa, 3.4 voyages per year, cargo tons.....	14,890	50,666	18,030	61,302

Electric Propelling Machinery of Future United States Capital Ships

THE present naval programme of the United States is the most extensive ever undertaken by any nation. We are now rapidly completing six battleships of the *Tennessee-New Mexico* class, and while these vessels are today unequalled in military power, they will become secondary as soon as representatives of two new classes are put into commission.

These new classes consist of battleships and battle cruisers, which will compare with the *Tennessee* as follows:

	Tennessee	New Battleships	New Battle Cruisers
Length overall, feet	624	684	874
Beam, feet.....	97	105	90
Draft, feet.....	31	33	31
Displacement, tons	33,000	43,200	43,500
Speed, knots.....	21	23	35
Main battery.....	12 14-inch guns	12 16-inch guns	8 16-inch guns
Shaft horsepower.	30,000	60,000	180,000

The new battleships are to be electrically driven, and the main propelling equipment of four of them—the *Indiana, Montana, South Dakota* and *North Carolina*—will consist of two Westinghouse 28,000-kilowatt turbine generators and four 15,000-horsepower Westinghouse propeller motors. The turbines are to be of the complete expansion, impulse-reaction type, and will develop their full rated load at 265 pounds steam pressure, 50 degrees superheat, and 28½ inches vacuum. Electric power will be generated in the form of 3-phase, 60-cycle, 5,000-volt alternating current.

The statistics of the new battle cruisers given in the table indicate that these vessels are to be very unusual in many respects, but their most remarkable feature is the enormous power of their turbines—180,000 horsepower, or 160,000 kilowatts.

These figures do not, however, give an adequate conception of the magnitude of this power. Not only is it greater than that of any ship ever designed—for the power of the British cruiser *Hood* is 134,000 horsepower and that of the *Leviathan* 90,000 horsepower—but it is greater than that used by most cities of over a half a million inhabitants.

Two of these vessels, the *Ranger* and the *Constellation*, will have the following equipment:

Four Westinghouse main turbines to develop 49,750 brake horsepower each, with steam at 265 pounds, 50 degrees superheat, and 28½-inch vacuum.

Four 40,000-kilowatt Westinghouse generators, directly connected to these turbines and generating 3-phase, 51.3 cycles, 5,400-volt alternating current.

Eight wound-rotor Westinghouse motors (two to each propeller), which are to be rated at 22,500 horsepower each, and will be the largest in the world.

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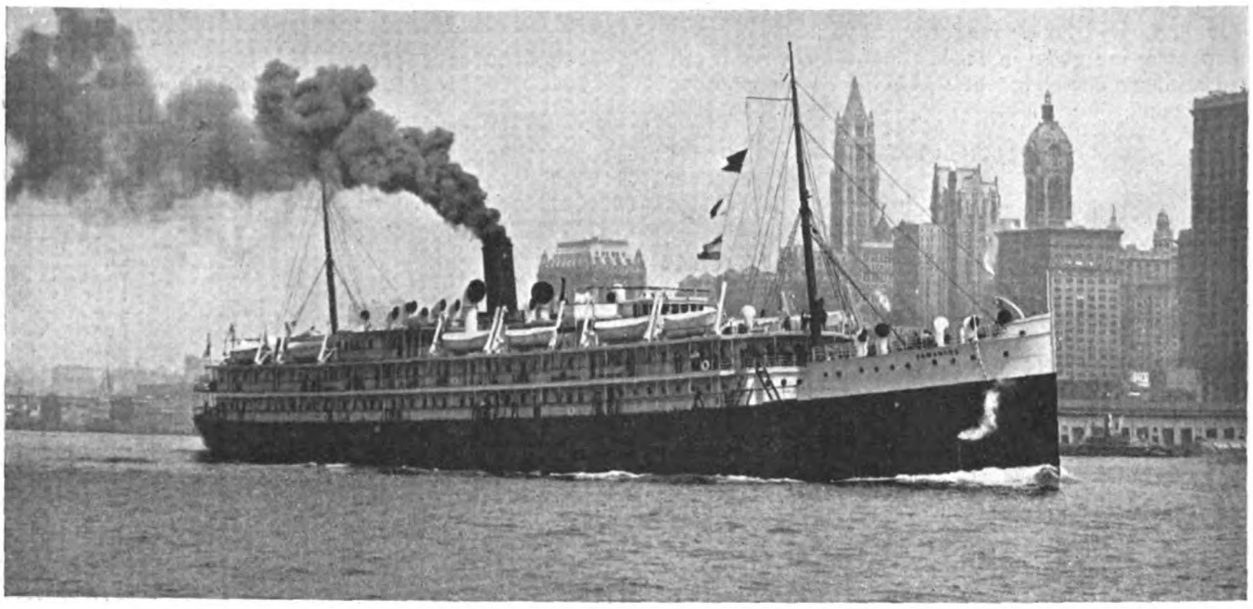

Fig. 1.—S. S. *Comanche* After Being Reconditioned

Rebuilding the Steamship Comanche

The rebuilding of the S. S. Comanche of the Clyde Steamship Company, New York, recently completed by the Tietjen and Lang Dry Dock Company, Jersey City, N. J., was one of the biggest alteration and repair jobs ever turned out by a shipyard. With the co-operation of Theodore E. Ferris, naval architect for the Clyde Steamship Company, the work was taken in hand and practically a new steamship was turned out by the men at the Tietjen and Lang yard.

DUE to the hard service in which the Clyde liner *Comanche* had been used by the Government and the little opportunity for repairs, even of a minor nature, there was much to be done when she was taken in hand for overhauling. Because of the extensive changes in the arrangement of the vessel she was "inclined" or heeled at the dry dock, so that the designer could determine the exact center of gravity of hull and machinery. This was done before anything was changed from the old rig.

Given free hand, the Tietjen and Lang men then stripped the hull down to the hurricane deck. Men were busily engaged in cleaning the outside of the hull plating while she was in dry dock, scaling and painting. The propeller and tail shaft were carefully examined and any parts that showed signs of wear were replaced by new fittings.

Machinery Overhaul

The main engines, which are of the reciprocating type, were given attention by the shipyard machinists, the cylinders being re-bored and other parts of the machinery being overhauled and replaced where needful. The condensers received new tubing and all auxiliary pumps were taken out and new ones put in their place.

A new engine room skylight was built, giving plenty of

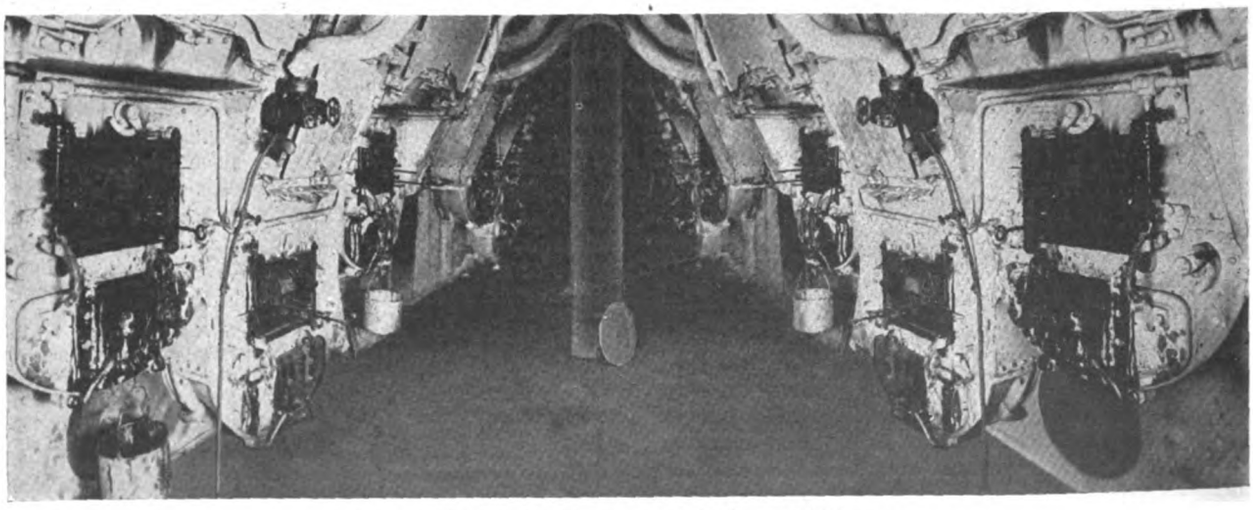

Fig. 2.—Fireroom After Conversion of Boilers to Oil Burners

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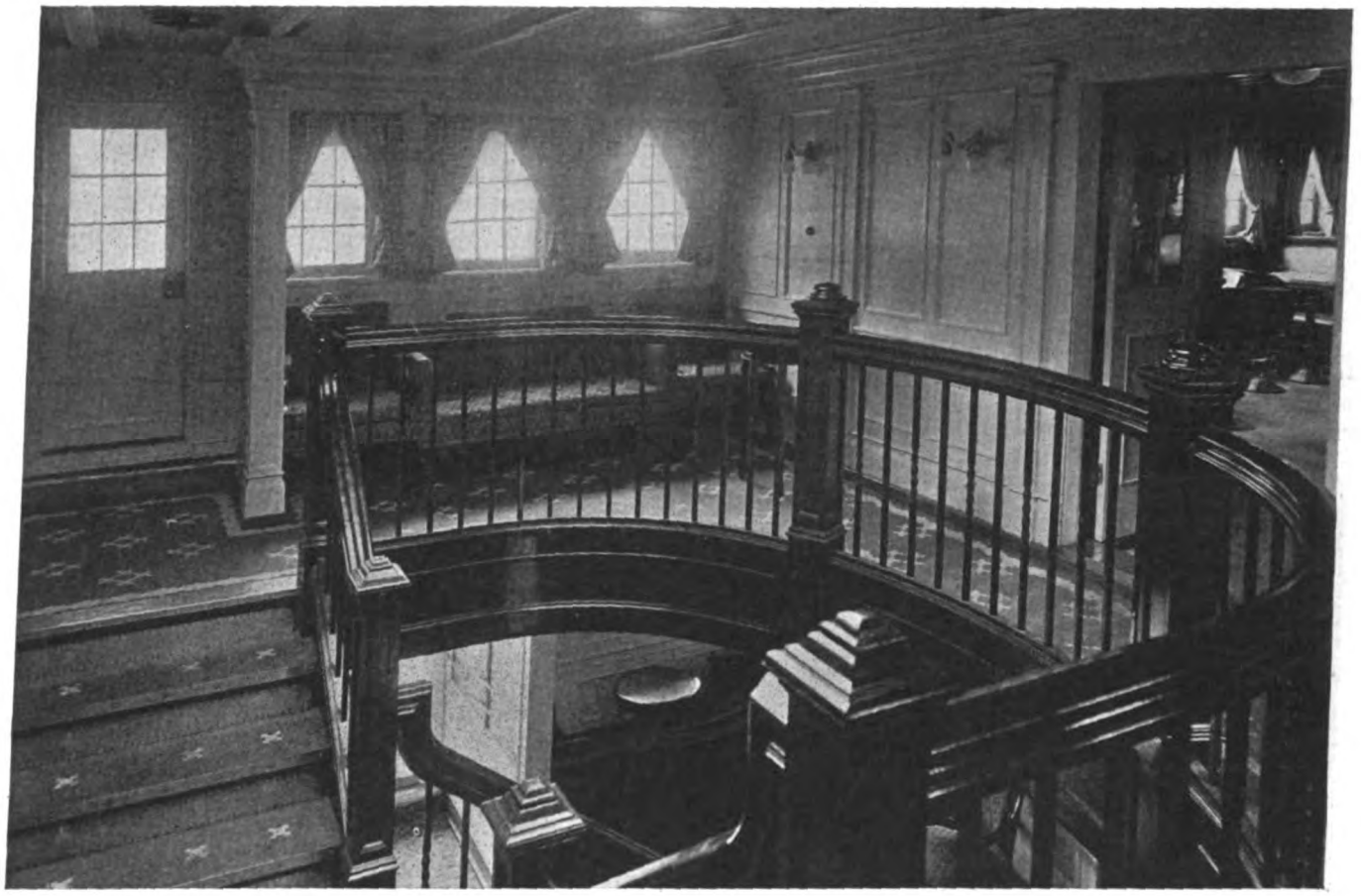

Fig. 3.—Main Stairway

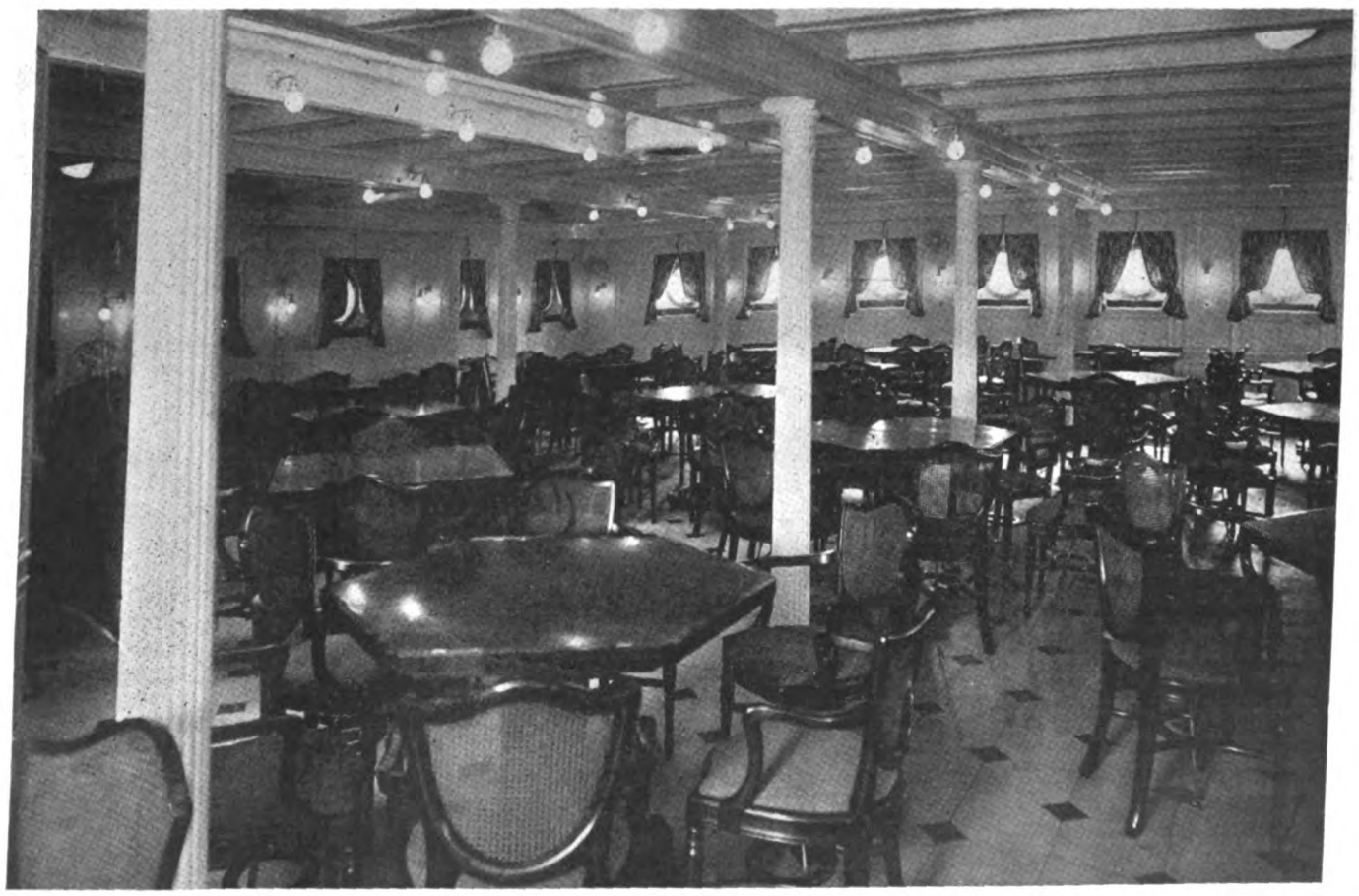

Fig. 4.—Dining Saloon

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light and air to the force below. Gratings and ladderways lead from the operating platform up to the quarters of the engineers and oilers.

Converted to an Oil Burner

One of the big changes in the new arrangement consisted in altering the fuel system from coal to oil burning in the boilers. The old boilers were taken out and four new ones installed in their places. These were designed to burn fuel oil with nozzles fitted with the White Fuel Oil Engineering Corporation patent type.

In order to accommodate the new fuel it was necessary to make alterations in the existing bulkheads and a number of new ones added to suit the special requirements for oil storage, such as room for expansion, swash plates, etc. As it was desired to have at least 3,000 miles steaming radius, space was required for about 390 tons of oil.

New Piping System Installed

With the placing of the new boilers the pipe shop gang of the shipyard was given a large amount of work in fitting a new system of piping for steam and carrying of the oil fuel from tank to tank and from tank to boilers. Practically all of the old piping was taken out of the ship and new material put in place. The necessary pumps for handling the oil were installed as new fittings. Piping for supply and discharge as well as to heat the oil was carried all through the various tanks and wells, this being a big job in itself.

With new cowl ventilators and a new boiler hatch the force in the boiler room is now given light, air and good working conditions. Many of the firemen now attend to their duties clad in white canvas clothes.

The hull of the vessel remained intact except for the renewal of ten plates amidships, on both sides of the hull.

Changes in the Hull

In No. 3 cargo hold the frames and reverse frames were taken out and new ones fitted in their places. In order to carry the strength of the ship up to the additional decks many of the main frames were cut at the main deck and spliced with an extra length.

Above the hurricane deck the vessel was entirely rebuilt. In order to sustain the extra weight when in a heavy seaway and to resist the racking strains which come at such a time, additional web frames were fitted about twenty feet apart for a considerable distance in the length of the ship.

Fig. 5.—Lounge

An entirely new promenade deck, carried out to the side of the vessel, was built as a "joiner deck," that is, with wood planking and steel tie plates along the edges of the deck and deck openings.

Accommodations

On the old hurricane deck a wood deck house was carried amidships and in it was built some of the first class staterooms and dining room. The main dining room is an attractive compartment, located in the forward end of the house. There are many airports which give plenty of light and ventilation. Electric fans are so placed as to give a steady current of cool air to those at the inner tables while the arrangement of electric light fixtures is pleasing to the diners.

The chairs, of pleasing design, light and well upholstered, are secured to the deck by a turnbuckle so they may be easily removed and yet are steady when the ship is in a

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seaway. By using this kind of furniture the heavy, massive appearance so often seen on ocean-going steamers has been avoided. The tables have been arranged to seat four or six people. The whole atmosphere of the room is light and airy. The mahogany sideboard is finished in natural color, all the paint work is a dull white, the panels of the ceiling being lined with gold stripes. The small serving tables near the dining tables are fitted with steam coils under them, serving to keep them warm and also to heat the room.

The pantry and galley, with its bakery, scullery, new cooking ranges, steam tables for keeping the food hot and rows of dishes are in keeping with a well-ordered ship. Sanitary tiling on the deck helps to keep it all neat and clean.

The officers' mess room is just aft of the galley and the sailors' mess room aft of that again, thus making the problem of feeding the ship's company very easy and simple.

As these mess rooms are on the port side, there is provision for a long passageway from the main dining room, aft to the stern, passing staterooms and social halls.

There are a few such social halls located in convenient corners having a table and a few chairs where passengers may sit and chat or write, as they may please.

First Class Staterooms

The first class staterooms, of which there are one hundred and five, including ten suite rooms, have two berths, settee, toilet, basin, mirror and locker. The curtain hanging in front of the air port gives a pleasant look to the interior, and with the white bulkheads, mahogany trim to the blinds and front of berths and carpet on the floor it compares well with any of the large transatlantic liners.

The suite rooms have either two single beds or one large double bed. A full length mirror fastened to the bathroom door, electric fan, four or five electric lights, wall and dome, make it very comfortable for the voyager. The bathrooms are large and well equipped with toilet and tub, shower with hot and cold fresh and salt water.

Promenade and Boat Decks

Above the promenade deck a similar wood deck house has been built and above it the boat deck. In the forward end of this deck house the lounge is located, being attractively furnished with piano, chairs, settees and writing tables. From here one may obtain a fine view ahead, looking over the forecastle.

A long passage on this deck connects the lounge with all of the passenger staterooms on the same deck. Two large stairways serve the two decks for use of the passengers. These have mahogany rails, art iron balustrade and heavy brass nosings and kick plates.

The steerage passengers are accommodated aft on the main deck. The men have a large compartment fitted with beds on one side of ship and eating tables on the other side. The women are on the deck above and have four-berth staterooms. They have a separate mess room from the men and are well provided for.

As all of the accommodation for passengers has been entirely rebuilt, it has been necessary to install a complete new system of ventilation for the staterooms as well as new plumbing and sanitary systems, together with their fittings.

The boat deck has been carried out to the ship's side to accommodate the stowage of the lifeboats. There are four patent lifeboats and ten steel boats of the regular type.

Officers' Accommodations

The large and well-arranged pilot house is finished in quartered oak as well as the captain's cabin, which is just abaft it. On the boat deck, cabins for the ship's officers have been built so they are comfortably situated, with baths and showers in special compartments. The captain's cabin has a separate bathroom for his use.

A new forecastlehead has been built and serves to house the stewards and other mess attendants, the forecastle deck being fitted with the usual deck gear.

The Smoking Room

The smoking room, headquarters for the veteran sea-voyager, is on the boat deck and is one of the most attractive rooms on the ship. A regulation "bar" of the pre-war type is built on one side. Well-designed built-in seats with card tables conveniently placed are suited to the most exacting taste. The quartered oak finish of the room is well set off by square windows having nine small lights of glass. Curtains in front of these windows are drawn back, giving plenty of light to the interior. This is added to by the large light-well which is carried up through the center of the room.

Swivel chairs are secured at the sides of the card tables. Electric lights in the shape of balls are secured to the sides, while above dome lights help to give a bright appearance to the room.

A tile finish on deck is set off by panels on the ceiling, these being divided into squares by oak strips. All paneling on the ship is a patent fibre board, very hard and one which takes the paint with good effect.

Aft of the smoking room is the shelter deck, so-called, as it is really a large room with the after end left open for air and a fine view of the ship's wake. The sides of the room are protected by walls fitted with glass sides, but the end is all open to the weather. The wood here is of teak, finished bright. For the benefit of the passengers in rainy or hot weather a heavy awning is stretched over the end of the boat deck so that passengers from the smoking room may pass out onto a weather deck without inconvenience.

To offset the additional superstructure, about one hundred tons of ballast was added, with the result that the ship is now "steady as a church" in a heavy sea and is winning praises from her navigating officers.

The *Comanche* as she now floats is as good as a new ship to her owners.

Annual Meeting of American Society of Mechanical Engineers

THE 1920 annual meeting of The American Society of Mechanical Engineers will be held in the Engineering Societies Building, 29 West 39th street, New York City, from December 7 through December 10. Sessions will be held on the subjects of Appraisal and Valuation and the Application of Engineering to Woodworking. The newly founded Professional Sections on Management, Power, Fuels, Machine Shop, Railroads and Textiles will also conduct sessions to consider the vital problems in their field. In addition, a number of valuable papers will be presented at General Sessions. A memorial session for Dr. Brashear is planned as a fitting tribute to his life and work.

The executive committee of the Metropolitan Section of the Society has decided to hold a series of joint meetings throughout the year with the New York Section of The American Institute of Electrical Engineers. In general the subjects selected for these meetings will come under the following classifications: Marine Engineering, Engineering Education, Industrial Installations, Power Generation, Steam Railroad Electrification, and Industrial Relations. It is intended to hold the first meeting in October.

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The Cost of Inefficiency at Our Terminals

BY HARWOOD FROST*

One of our favorite topics of conversation of late has been the high cost of living. As a contributory cause of no small importance to this distressful state of affairs, Mr. Frost estimates an annual waste of no less than $400,000,000 at our terminals due to inefficient equipment and methods. Figured as interest at 5 percent, this represents a capital sum of $8,000,000,000 tied up by inefficiency in handling freight. Such waste is preventable and the author indicates the way in which it can be eliminated.

WE have been told that the high cost of living is caused by profiteering, by high labor costs, by underproduction, by the excess profits tax, by inflation, extravagance and other causes, most of which can be traced directly or indirectly to the war. No one or two of these factors can be said to be *the* cause of high prices. They, with many others, are all contributory, and among these other factors are the wastes involved in the traffic in goods or in the handling of materials in transfer.

The railroads and the water routes are the lanes over which the traffic passes, but the ends of these lanes are our railroad and marine terminals, and through them passed goods representing last year a commerce of nearly ninety billions of dollars, representing a per capita expenditure of $806.

$30,000,000,000 Wasted Through Inefficiency

It has been stated by authorities that of this expenditure about *one-third*, or a total of between 25 and 30 billions of dollars, can be traced to inefficiency and preventable wastes in our methods of handling materials in transfer from producer to consumer. This enormous sum—a sum much greater than the total issue of Liberty Bonds—is incorporated in our expenditures by a system of multiplication and addition in the progress of commodities from the source, through the hands of the middleman, to the consumer. It plays an important part in making up our present high cost of living, largely because of indifference of shipping interests, political influence and ignorance of the general public to the conditions which exact this burdensome and unwarranted tax.

Waste in materials-handling methods hampers production and there cannot be any doubt that this unnecessary tax of between 25 and 30 billions of dollars has a most serious effect on one of our great problems—underproduction.

The handling of commodities is purely a non-productive expense. No amount of lifting and hauling increases the quality or the intrinsic value of the article. The ultimate price depends on transportation and handling. As the goods pass from producer to consumer through the hands of wholesalers and jobbers each adds his profit in addition to his expenses; as the bags or other packages are loaded into cars or ships, unloaded and trucked across docks and warehouses, piled for storage and otherwise handled, each handling increases the ultimate cost.

> An important reason for the neglect in providing mechanical equipment at our terminals is the skepticism of managers, foremen and contractors in charge of terminal and warehouse works, who have, in many cases, grown up from the ranks and have never considered the subject beyond the limitations of their own experience. This ignorance and skepticism can often be extended to embrace those in higher authority, especially where the control of the terminal is subject to political influence. At some of our ports the authorities are planning to spend vast sums for new piers and harbor facilities, with little or no regard to provisions for economy or speed in the handling of the freight. The result will be that the whole nation must suffer and pay for this lack of efficiency in our terminal facilities.
>
> —*Harwood Frost.*

Possible Savings in Rail Transportation

The railroads of the United States handle under normal conditions over one billion tons of miscellaneous freight annually, as was shown in the Interstate Commerce Commission report of 1914, the handling of which, not including the rail haul, costs from a few cents up to 50 cents per ton, and in some special cases much more, depending on many varying conditions. It is asserted that from ten to thirty cents a ton can be saved by the introduction of mechanical equipment, which would indicate, at an average saving of even 15 cents a ton, a saving to the railroads of about $150,000,000 a year on each handling. As all this freight is handled at least twice, the possibilities in saving would be double this figure—$300,000,000 per annum. The facts are, however, that much of this freight is handled five, six, seven or eight times, exclusive of the hauling.

And yet there is not one single railroad terminal in the United States completely and efficiently equipped with mechanical appliances for the handling of package freight.

Our Wasteful Marine Terminals

In the marine field it is estimated that under normal peace-time conditions, considerably over 300,000,000 tons of miscellaneous freight are handled at our seaport terminals every year. The conditions of handling in this field and the costs are essentially the same as in the case of the railroad terminals, so with an average reduction in cost of 15 cents per ton there would be an approximate annual saving of $45,000,000 on each handling, and as this freight also must be received inward and shipped or delivered outward, the possible saving would be ninety million. Add to this $10,000,000, which is a most conservative estimate of the saving that might be effected in handling the vast tonnage of our inland waterways and lakes, and we have a possible saving of one hundred million dollars a year in the terminal handling of our water-borne commerce.

And yet there is not a single marine terminal in any one of the hundreds of ports in the 5,000 miles of sea coast of the United States, nor a single lake or river port in the thousands of miles of our navigable waterways completely and efficiently equipped for the handling of package freight.

* President, Brown Portable Conveying Machinery Company, Chicago, Ill.

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If these figures may be considered as even approximately correct, the railroads can save $300,000,000 every year by improved methods and the steamship and steamboat companies can save another $100,000,000 a year. In other words, the transportation or terminal operating companies of the United States are unnecessarily wasting $400,000,000 of their stockholders' money every year by lack of efficient handling methods.

$400,000,000 Wasted Annually

The savings effected by a properly co-ordinated system of mechanical freight handling equipment run from 10 to 80 percent, according to the many conditions affecting each particular installation, but 40 percent may be considered as a fair average. If we assume the average possible reduction of 15 cents per ton in the expense of each handling to be represented by this 40 percent, then this $400,000,000 would represent an expenditure for labor alone of about a billion dollars a year, which is actually less than the amounts so expended at our terminals.

Labor-Saving Machines Pay Their Way

Experience has shown that where labor-saving machines of this nature are in fairly continuous use, the savings they effect will repay the investment in from six to eighteen months. From this rough basis we may estimate that the value of the equipment necessary to effect a saving of $400,000,000 a year, repaying its cost in approximately fifteen months, would be $500,000,000—only 6 percent of the labor investment represented in the annual waste, only half of the actual labor cost of one year, and only 2½ percent of the amount of Liberty Bonds bought by the American people.

But this is not all; these figures refer to labor only. Add to this possible saving of labor the savings due to quicker deliveries of goods, the saving due to quick release of cars, ships and trucks, the elimination of damage to packages, the prevention of loss of perishable freight, etc., and you can well realize that any substantial proportion of these combined savings for a single year would be sufficient to pay for the erection and complete equipment of a large number of terminals, and that the elimination of such wastes would mean the transfer of thousands of laborers from non-productive to productive work.

Terminal Expenses Many Times the Cost of Hauling

It has been estimated that the average expense of hauling a ton of freight 240 miles is 74 cents, while the average expense of handling the same ton of freight at the terminals is 75 cents; that is, the terminal handling charges equal the freight haul of 240 miles. As an example of the expenses involved in the short haul from New York to Philadelphia by rail, the cost of handling at the terminals is $3.65 and the railroad cost for the 90-mile haul is 27 cents. The terminal expenses are nearly fourteen times the rail haul.

It costs as much to deliver a shipment from a freight terminal in New York to the hold of a ship as it does to transport it by rail from Chicago to the New York terminal. The 1,300-mile marine haul from Havana to Boston is cheaper than the transfer from one pier in Boston Harbor to another. It costs more to load a box of canned goods on a car in Chicago than it does to carry it by rail from Chicago to New York. It costs more to transfer a barrel of flour over the wharf and to the hold of a ship in New York than to carry it by that ship from New York to Liverpool. It is said that the waste caused by idleness of motor trucks at terminal points due to inefficient loading methods and congestion is over $250,000,000 a year.

New York, where half the nation's imports and exports are handled, is planning to build a terminal practically devoid of modern materials-handling appliances. New York plans to spend many millions of dollars on docks of exactly the size and type built in the days of the "clipper ship," with no regard to a possible decrease in handling costs to America's manufacturers and distributors.

But we are all paying our tax for New York's inefficiency in the price of every pound of sugar we eat, every cigar we smoke, every cup of coffee we drink; we are paying for it daily in every dollar we spend. It cannot be said that the terminal problem is a local one that affects New York, Seattle or New Orleans only. It is a national problem that affects every one of us.

> Large sums have been appropriated for the improvement of American harbors, for the construction of new piers and the improvement of old, for the building of terminal warehouses, and for the installation of equipment. Millions will be spent on these improvements; but, unfortunately, millions will also be wasted by incompetent advice and improper design of warehouses and handling equipment, due largely to lack of experience and lack of education in this field of engineering, and also through lack of unselfish co-operation among manufacturers. The shortage of labor calls for the use at our ocean, lake, gulf and river terminals of winches, hoists, telphers, battery trucks, tractors and trailers, tiering machines, conveyors and all other possible devices that will utilize manual labor in the smallest degree; that will not only hoist or lower the freight between the dock and the vessel's hold, but that will transfer, tier and reclaim, and that will do so at such a speed as to materially reduce both the time of actual handling of this cargo and the idle time of the carrier.—*Harwood Frost.*

Where Real Economy Can Be Secured

America has invented and manufactures more modern freight handling machinery than any other country in the world, and *uses* comparatively less. Still we are building up a merchant marine in an effort to compete for the world's trade and at the same time neglecting the very methods that made for the profitable operation of many foreign ports and that contributed largely to the normal low cost of living in these foreign countries.

Not until our terminals are properly designed with regard to the goods to be handled, and adequately equipped with machinery that will reduce both the time of the cargo and the idle time of the carrier, will we be able successfully to compete with these older, more experienced and more efficient maritime peoples, and only when the general public has been enlightened as to the economic effects of our present wasteful methods and aroused to the realization of its powers and responsibilities in the matter will we have efficiency in place of the present chaos and a terminal system that will be a credit to the engineering ability of the American people.

Terminal Improvements to Be Recommended.—Constructive recommendations looking to an improvement in the handling of freight in the terminals will be made soon by the railroad committee of the Chamber of Commerce of the United States. The suggestions are under preparation following a meeting of the committee at which a report on the terminal situation was made by its secretary.

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Comment from the Shipping World

BY "OLD SCOTCH"

The merchant marine situation is now passing through a phase of uncertainty which is a natural sequence of after-the-war psychology. The troublesome times caused by the apparent success of the Russian miserables in the assault on Poland has for the time being unsettled the world's financial markets, already in a chaotic condition, but showing signs of recovery. Now, however, that the Shipping Board has announced a plan for the disposition of the Government-owned ships and several applications for the exemption of the war profit taxes to be used for the construction of new vessels have been made, it is hoped many new shipping and shipbuilding enterprises will be undertaken which have been held back on account of the adverse outlook.

IF people looked only on the dark side of situations as they arise, the world would make little advancement. Fortunately now, as at all times when things look darkest, there are some silver linings to the clouds of doubt and uncertainty which may seem to envelop us. Let us then be cheerful and consider that at times during the French revolution, which almost parallels present conditions in Russia, the world's affairs looked darker than they do today; yet out of it all came a decided advance in the stability of constitutional government. In spite of pessimistic forecasts by so many nervous observers who return to our shores it is not written in the world's horoscope that this seething mass of half-crazed Russians will undo the constructive work of centuries. Law and order are bound to prevail.

Notwithstanding the long delay, the new Shipping Board must eventually be appointed, and it is understood that the sales policy for the Board ships has practically been decided upon by the present members and will soon be promulgated. Ocean freight rates in common with all other inflated prices must naturally come down to normal conditions sooner or later. Hard times are generally the aftermath of over production, but the world is not suffering from any such condition—under production is the main trouble at present, and before normal conditions are arrived at there must be a tremendous amount of work performed by the human race, and ocean transportation will be one of the main activities.

Peak of High Costs Reached

Times such as the present are productive of good, inasmuch as it gets us in a humble mood and causes us to think over the future. The whole world is recovering from a protracted spree of riotous living caused by the inflations incident to the war. The "cold gray dawn of the morning after" has always resulted in firm resolves to do better. Let the marine world resolve to cut out the waste and profligacy of the past two or three years and get down to rigid economies in everything connected with shipping.

We must do it anyhow, if we are to continue our development of a merchant marine in all its functions. The Shipping Board is setting the pace, as its members realize the vital importance of making both ends meet, now as never before. Evidences of it are seen in every move at present. Agents abroad are cutting out the reckless expenditures heretofore encountered and getting down to brass tacks. The repairing of the ships is receiving closer scrutiny, and while nothing is being done to reduce efficiency, the new supervisory system is productive of great savings. The new insurance syndicates are functioning and already a great deal of the premiums heretofore placed abroad are being received by American companies.

While it is doubtful if the building costs of ships have been reduced, owing to the continued high prices for labor and material, we certainly have reached the peak of high costs and from now on cheaper costs may be confidently anticipated. The recent sale of two practically new Skinner and Eddy cargo ships to the Steel Corporation at a reported cost of about $144 per deadweight ton seems quite indicative of what the Shipping Board may have to fix as the selling cost of many of its ships. Under present circumstances it does not seem probable that any of this vast fleet will sell for much more than that rate per ton, with the almost certainty of gradually decreasing prices as the sale proceeds.

The Government, viewed in the light of a strictly business transaction, stands to lose a great deal of money, if the sales are consummated in accordance with the above assumptions, but that is not the correct viewpoint to take. Our fleet of merchantmen should be considered as a war expenditure, and if from a salvage standpoint the Government realizes only 50 percent from its investment in ships, it will get out of this investment much better than it has from any other of its major war expenditures. In addition to the returns of a direct monetary nature, there will be the indirect returns extending to all branches of industry in this country due to the rehabilitation of a merchant marine commensurate with the needs of our national business. This, we all must admit, could not have been accomplished without the expenditure of enormous sums in direct subsidies, so that viewed in a broad light Uncle Sam's investments in merchant shipping have not been so bad as some might imagine.

Bids for Naval Transport

Opinions as to the cost of ship production at the moment are very varied, but few authorities agreeing on the subject. Perhaps opinions backed up with bona fide bids for new construction are the most reliable, but even those are far apart, as evidenced by the proposals recently submitted for a naval transport. The proposed ship is to be 484 feet long, of about 10,000 tons displacement, and to have a sustained sea speed of 16 knots. With several exceptions caused by military necessities, she will not vary greatly from an ordinary passenger vessel of that size. Of the seven proposals received for her construction, the lowest one was from the Morse yard at Alexandria, Va., in the total sum of $2,493,000 with an agreement to complete the vessel in 16 months. The other bids mounted upward until the maximum estimate of $6,950,000 and 30 months for completion was recorded. This ratio of 2½ to 7 seems to represent in finite terms the indefinite ideas of shipbuilders generally as to the fluctuations of materials and labor for the next year or so. As before remarked, these be chaotic times we are passing through at this writing.

We have become so accustomed to enormous figures in

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money and commodities as incidents of the great war that nothing seems to surprise us. From a marine engineering standpoint, now that we have time to reflect, is there anything more stupendous to contemplate than the designed power of the new battle cruisers now under actual construction at several of our leading yards? Just think of 180,000 horsepower to be installed in one single ship! Perhaps we can better grasp the idea by considering that that amount of power would be sufficient to propel over half a million tons of the average-sized merchant vessels. The combined propelling power of no less than 70 of the Hog Island ships will just about equal the power that is to go in one of these battle cruisers. Let us hope that the Geological Survey will, in the meantime, get busy and discover more oil fields if these monsters are to cruise about to any great extent. In addition to these oil consumers, there are now building four new battleships of the ordinary dreadnought type, each to have 60,000 horsepower, sufficient to run fifteen of the largest merchant ships we have built. If fuel oil should continue its skyward course in price, who said there would be a reduction in our Federal income taxes in the next few years?

AFTERMATH OF THE CUP RACES

Although the historic America's cup is to stay in our possession for at least another year, there seems to be a general public attitude of dissatisfaction concerning the outcome. In the first place the general public was precluded from witnessing the races because our laws relating to safety of ships at sea limited the sight-seeing craft to two or three high-priced observation craft. Added to that is the general fair-minded American attitude that one-sided events are not productive of the best in sportsmanship of this character. Above every other feature connected with the races was the postponement of one of the events solely because there was too much wind blowing. After repeated flukes and drifting matches, the average man interested in the sport was somewhat disgusted with the idea of there being too much of a desired element. The truth of the matter is that yachts designed for these great international events have degenerated into purely racing machines, designed for mild weather only. To have raced them on that windy Saturday afternoon in July would probably have resulted in a fatality, so the managers were wise in postponing it, as they did. There is a well-defined rumor going around that hereafter all racing yachts must be classed by an American classification society and their seaworthiness assured under all conditions of weather. Who could imagine the original schooner yacht *America* failing to go out and sail a race because the wind happened to be fresh?

Syndicate A of the new Underwriters' Association to take over the insurance on American ships and cargoes is being formed and will soon be functioning. This syndicate will be devoted entirely to survey work and its activities will be very much similar to those of the London Salvage Association. Mr. Charles R. Page, a gentleman who has been connected with marine insurance companies for many years, and recently a member of the Shipping Board, will be the director of the new syndicate and will shortly take up his headquarters on Beaver street in New York City.

JULY SHIPBUILDING RETURNS.—The Bureau of Navigation, Department of Commerce, reports 171 sailing, steam, gas and unrigged vessels of 214,840 gross tons built in the United States and officially numbered during the month of July. Of this amount 24 vessels of 147,699 gross tons were built for the United States Shipping Board.

Welding a Lighthouse Foundation

DURING the arctic winter of 1917-1918, when zero weather paid frequent visits even to the Carolinas, a most unusual accident happened to Wade Point lighthouse, which is situated one mile from shore in the northeasterly part of Albemarle Sound, N. C.

A large ice-flow which had formed in Albemarle Sound became detached by a terrific gale, and was driven with great force against the five cast iron columns which support the superstructure of the lighthouse in a depth of 9 feet of water. So great was the pressure of the ice after it had piled up on one side of the structure that the columns were bent over in a northwesterly direction and broken through, the columns below the breaks standing at an angle of about 20 degrees with the vertical.

When the question of making a permanent repair was under discussion by the Lighthouse Service, it was decided to weld the columns by means of the thermit process instead of putting in new foundations, the cost of which would be excessive.

Wade Point Lighthouse With Temporary Wooden Pile Construction and Three Welds Completed (Two Front Corners and Left Rear Corner)

Owing to the isolated situation of the lighthouse all welding materials were transported from Norfolk, Va., by a small steamer, which was moored alongside the lighthouse during the welding operation and served as quarters for the men.

It was first necessary to jack up the superstructure in order to remove the weight from each column successively as it was being welded, also to control the allowance for the contraction of the weld.

In spite of the intense heat of the thermit reaction no injury occurred to the lighthouse.

Each weld was allowed ample time to cool, after which the mold box surrounding the weld was dismantled and the thermit steel pouring and heating gates and risers cut off.

Each of the welds, all of which proved entirely satisfactory, required from 125 to 175 pounds of thermit, according to the size of the opening cut out.

The actual time consumed in making the five welds was a little less than three weeks.

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Marine Engineering

Published Monthly by
SIMMONS-BOARDMAN PUBLISHING COMPANY
6 East 39th Street and Woolworth Building, New York, N. Y.

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MARINE ENGINEERING is a member of the Associated Business Papers, Inc., (A. B. P.), National Association of Periodical Publishers, Inc., New York Business Publishers Association and the Audit Bureau of Circulations (A. B. C.).

The Shipbuilding Situation

ALTHOUGH contracts for new ships have not been coming in as fast as we would like to see them during the last few months, the fact still remains that the yards, as a whole, now have a total tonnage on their books for private account that is very much greater than it was a year ago. On July 1, 1919, there were under contract for private owners only 16 ships of 83,910 gross tons, while according to a report of the Atlantic Coast Shipbuilders' Association dated July 31, 1920, the American shipyards had a total of 307 steel vessels of 1,454,102 gross tons building or under contract for private owners. Transferring the gross tonnage into approximate deadweight tonnage, and multiplying by $200, a price which is less than the Shipping Board has been asking for its best type of freighters, we now have ships building to the value of $436,230,600.

In addition to this, there are the vessels and warships building for the Shipping Board and Navy Department, an amount sufficient to bring the gross tonnage now building up to about 3,000,000. Considering that we are in a period of transition from the most stupendous shipbuilding activity ever attempted anywhere, when men from all walks of life were helping to build ships, to a permanent peace basis, the outlook for our shipbuilding industry should not be pessimistic. If we had had the amount of work now on the books in our shipyards at any time before the war we would have then considered it a shipbuilding boom.

Having taken stock of the amount of our present work, the question remains, "What are the prospects for future contracts?" We know that there is an insistent demand for tankers. The New York Shipbuilding Company has recently sold two stock tankers at $225 a deadweight ton, and it has been announced that this company will lay the keels for two or more tankers for its own account this fall. The Sun Shipbuilding Company and the Merchant Shipbuilding Corporation have between them thirty-seven vessels to build, most of which are tankers. Shipbuilders report that inquiries for tanker tonnage are increasing, and we know that some steamship lines are figuring on having their own tankers to insure a reliable supply of oil for their own vessels.

In regard to passenger vessels, we know that the International Mercantile Marine Company, the Munson Line, the Red D Line and others have been working on plans for this type of vessel for their respective lines. Mr. Edward N. Hurley, in his recent book entitled "The New Merchant Marine," has very clearly set forth the necessity of providing for adequate passenger service in American-built vessels. We know that established steamship lines have been very prosperous and are at present amply able to finance the construction or purchase of such ships as they need.

Another type of vessel that will take no small place in future construction is the motorship. The best proof of this is the fact that a large number of our shipyards and manufacturers of marine machinery have expended vast sums on the construction and development of the marine type of Diesel engine.

In conclusion, it should be noted that the object of the Merchant Marine Act is to provide for the development of shipping and shipbuilding and that both Republicans and Democrats are in accord on this subject. Is it reasonable to suppose that the operating companies are not going to save their excess profits taxes by investing them in the construction of new ships as provided for in the Jones Bill, or that no one will take advantage of the construction loan of $125,000,000 which this bill provides for the construction of the best type of vessels?

Safety of Ships at Sea

THE significant feature of the recent summer meetings of the British Institution of Naval Architects at Liverpool is that the strictly ship papers and the discussions thereon were devoted almost entirely to the problems of subdivision and safety of merchant vessels at sea. In connection with this it is interesting to note that at the last meeting of the American Society of Naval Architects and Marine Engineers, which was held in New York last November, Professor William Hovgaard, under whose direction the calculations of stability involved in the conversion of the German liners into troopships were made, presented a paper entitled *Buoyancy and Stability of Troop Transports*. Aside from the fact that transports usually carry more persons than passenger liners of the same size and the vital importance of the safety of troops in time of war, the principles outlined in this paper are equally applicable to merchant vessels.

The three great marine disasters, namely, the sinking of the *Titanic*, of the *Lusitania*, and of the *Empress of Ireland*, where in each case over a thousand lives were lost, have evidently made a profound impression on the minds

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of the British naval architects. The shipowners, however, who are the people most concerned in this question from the standpoint of first cost and operation, which will be vital factors in the forthcoming struggle for international shipping supremacy, did not take the opportunity to present their side of the case. It is certain that a satisfactory solution of such problems as the subdivision of vessels into watertight compartments by transverse bulkheads, the length of steps or recesses in bulkheads, proper openings in longitudinal bulkheads to prevent serious listing when bilging occurs, watertight doors, sidelights below the bulkhead deck, etc., cannot safely be left to indivdual concerns who are apt to rely too strongly on the navigating ability of their captains.

An International Convention for the Safety of Life at Sea, composed of representatives of the principal maritime countries, was held in London in 1914 and subsequent recommendations were made by the British Board of Trade, but, owing to the war, no action has been taken by any country except England, which has recently decided to enforce rules that are similar to those recommended by the Convention. England deserves credit for showing us the way in this matter, but she is thereby placing a handicap on her shipping in the way of cost and operation. We in the United States have safeguarded our railroads and industries with all kinds of safety rules and devices, and it is to be hoped that we will follow suit in this matter by enacting laws that will make our passenger vessels as safe as it is possible to do. In the long run this will be found the best policy, as the public will travel on those vessels in which they have the most confidence, be they American or British.

Those who have constructed curves of floodable length for the proper spacing of watertight bulkheads will be interested in the simplified method proposed by Mr. George Webster in his article entitled *Subdivision of Passenger Vessels*, which appears on page 726 of this issue. This method eliminates a great deal of unnecessary work and allows the dimensions of a proposed vessel to be determined with greater dispatch. The substitution of depth for draft in the freeboard and sheer ratios does not appear to make a material change in the standard curves, but it does simplify the work. A simple and satisfactory method of calculating the permeability is also given which is a great improvement on the cumbersome alternative given in the Board of Trade rules. However, the greatest innovation presented in this article is a special slide rule which seems to be adaptable to easy manipulation. The question of the accuracy of this rule will, of course, be questioned, but more elaborate calculations than here required are made on slide rules and are found to be sufficient for the purpose.

Shipping men, as a rule, are slow to accept changes or new equipment, and rightly so, because a storm at sea is not an ideal place to try experiments, but this argument does not apply to the construction of a vessel on such lines that with careful navigation the loss of passengers, cargo or ship will be reduced to a minimum.

Cooperation

THE principle of cooperation between the individual institutions of an industry, based on the fact that only as the permanent prosperity and popularity of that industry is attained will the individual concern be assured of continued success is a truth of which most progressive business men are convinced. It is only natural to feel anything but sorry at a breakdown or failure in the product of a competitor, in spite of the fact that the industry itself suffers in the confidence of the public. Competition, which is known to be a stimulus to development, should be conducted on a live and let live basis along the lines of fair play, and criticism, if offered, should be constructive rather than destructive.

Nowhere is the interchange of ideas and mutual effort for the common good more necessary than in the shipping and shipbuilding field, because these industries have been so greatly extended during the last few years that we lack a sufficiently experienced personnel to compete efficiently with the leading shipping countries on a peacetime basis. Our policies will have to be worked out for the general good if we are to succeed, and it is for such purposes that the American Steamship Owners' Association and the Atlantic Coast Shipbuilders' Association are working.

Our merchant marine was built for a patriotic purpose and there is still a tendency to use patriotic reasons for its development, losing sight of the possibilities that shipping offers in the way of financial return. In the olden days the American boys took naturally to shipping because it was profitable, most of them expecting to become an East Indian merchantman, and the best way to secure the cooperation of the brains and capital of this country today is for shipbuilders and ship operators to work together in a large way and prove that the opportunities in this line are as great as in any other. The facts that the Atlantic Gulf and West Indies Company earned over 30 percent on its common stock during the last year on the one hand, and the incorporation of many new steamship lines on the other, may be cited as indications upon which to base an optimistic outlook.

Teamwork between the shipowners and shipbuilders, having the object of securing the best and most economical vessels for specific routes, will be found mutually beneficial. Our shipbuilding programme is by no means complete, as we lack not only tankers and passenger vessels but also special types of freighters. The cargo vessels constructed during the war are not the best type of ships for certain services, and the established steamship lines will undoubtedly give careful consideration to the operating expenses and earning power of specially designed ships, unless the cost of the Shipping Board vessels is sufficiently low to warrant their purchase.

The success of shipping and shipbuilding depends to a large extent on each other, but the prosperity of the nation, with its greatly expanded industries, is dependent on transportation facilities. Shipping is a subject on which we all ought to get together and boost as a means of safeguarding our future economic independence.

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LETTERS TO THE EDITOR

Method of Estimating Steel Hull Weights

I have read with considerable interest the *Method of Estimating Steel Hull Weights* published in the August, 1920, issue of MARINE ENGINEERING.

While I personally use the *Cubic Number Method* which the author describes towards the end of the article, I have noted a number of interesting points in connection with same which he does not mention, but which would undoubtedly affect his method, and which might possibly save some of the newer men in the shipbuilding game from making errors in the estimating of net steel weights.

As the displacement ratio of the vessel decreases, so does the cubic coefficient, at the rate of about 0.002 for a change of 0.01 in the displacement ratio; similarly, the cubic coefficient decreases about 0.001 for a decrease of 0.1 in the ratio of length to depth. The cubic coefficient is about constant for similar vessels over 400 feet in length, but below 400 feet in length it increases in a gradual curve to about 0.05 greater for a vessel 200 feet in length than the coefficient of a similar 400-foot vessel. The reduction of the coefficient which he gives for longitudinally framed vessels, compared with that of transversely framed vessels, seems rather low, as longitudinally framed vessels have almost invariably at least 6 percent less net steel than a duplicate vessel built on the transverse system, and frequently run as high as 10 percent less.

The corrections which I have given above to the coefficient due to displacement ratio, length to depth ratio, and length, are fairly accurate for small changes in these factors; but the coefficient correction curves are not quite straight lines and should accordingly not be used for extreme differences. The coefficients which he quotes (0.40 to 0.44 for transverse vessels) are, in my experience, hardly broad enough to cover the usual variations of vessels, as I personally know of many cases where this coefficient is as low as 0.03 for sea-going full scantling ships.

While I am of the opinion that the cubic number method can be used to give quite as accurate results (with a little care in comparing the new ship with the one on which the cubic number is based) as the method the writer of the article proposes, may I not suggest that he permit you to publish the numerous curves he proposes, so as to save the newcomers in the shipbuilding field the considerable amount of work necessary to prepare such a set of curves. They would also serve as an interesting check for those of us who care to continue using the *Cubic Number* method.

Vancouver, Wash. S. A. VINCENT, Naval Architect,
G. M. Standifer Construction Corporation.

Revision of Weights for Sections of Minimum Web Thickness of American Standard Beams and Channels

In 1896, The Association of American Steel Manufacturers adopted a list of standard profiles of structural steel sections which are known as American Standard Structural Sections. In 1911, the association also adopted standard methods of computation for published weights and areas. The weights that were published for the minimum thicknesses of beams and channels did not correspond exactly to the published areas and it has long been known that it is impracticable to furnish these sections true to both the published weights and dimensions.

To correct this situation, the association has just adopted as American standards the weights per foot shown in the third column of the table below for the sections of *minimum* web thicknesses which do correspond to the published dimensions.

Section	Depth, Inches	Weight, Pounds per Foot — Present Weight	New Weight
Beams	3	5.5	5.7
	4	7.5	7.7
	5	9.75	10.0
	6	12.25	12.5
	7	15.0	15.3
	8	18.0	18.4
	9	21.0	21.8
	10	25.0	25.4
	12	31.5	31.8
	12	40.0	40.8
	15	42.0	42.9
	15	60.0	60.8
	15	80.0	81.3
	18	55.0	54.7
	20	65.0	65.4
	20	80.0	81.4
	24	80.0	79.9
	24	105.0	105.9
Channels	3	4.0	4.1
	4	5.25	5.4
	5	6.5	6.7
	6	8.0	8.2
	7	9.75	9.8
	8	11.25	11.5
	9	13.25	13.4
	10	15.0	15.3
	12	20.5	20.7
	15	33.0	33.9

There is to be no change in the profiles and properties of sections of minimum web thickness nor in the weights and properties of the intermediate and maximum sections of American standard beams and channels.

The new weights are to be put into effect September 1 by all of the companies rolling these sections.

Pittsburgh, Pa. J. O. LEECH, Secretary,
The Association of American Steel Manufacturers.

NEW BOOKS

Ships' Boats

REVIEWED BY C. H. PEABODY, DR. ENG.

SHIPS' BOATS: THEIR QUALITIES, CONSTRUCTION, EQUIPMENT AND LAUNCHING APPLIANCES. By Ernest W. Blocksidge, M. I. N. A. Size, 5½ by 8½ inches. Pages, 500. Illustrations, 256. New York, 1920: Longmans, Green & Company. Price, $9.

The author of this book is ship surveyor to Lloyd's Register of Shipping, and formerly ship surveyor to the British Board of Trade, and has had the opportunity and taken occasion to make himself thoroughly familiar with the design, construction and use of ships' boats.

Mr. Blocksidge presents for the first time a complete and authoritative work on a very important branch of naval construction; the importance of life saving at sea is now recognized not only by the profession but by the public in consequence of the disasters to the *Titanic* and to the *Lusitania*, and has found expression in the report of the International Convention on Life-Saving at Sea; and this book is prepared with the findings of the Convention in view. His work is prepared for shipbuilders and shipowners of Great Britain, but is applicable with some al-

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lowance to the needs of the merchant marine of the United States.

The author begins with the history of requirements for lifeboats. Previous to 1890 the requirements for boats were based on the registered tonnage of the ship and had no relation to the number of persons aboard. In that year the rules for life-saving appliances adopted the principle that on all cargo vessels the boat accommodation should be sufficient for all on board. These rules substituted gross for registered tonnage, which increased the boat accommodations by fifty percent. Subsequent regulations somewhat improved matters, but at the loss of the *Titanic* the boat equipment was sufficient for only women and children and a few of the men. Hasty legislation in both Great Britain and the United States required the provision for all persons on board, both passengers and crew. For ships in commission it was impossible to make real adequate provision, and certain temporary devices were allowed for nominal compliance with the law. An ill effect of such hasty legislation is evident in the description of certain classes of boats described in this book.

Part II of the book gives the rules for the British merchant shipping as affecting boat accommodation and installation of davits, a classification of boats, and a discussion of form, stability, strength and capacity. We are naturally most interested in ships in foreign trade. For such passenger ships it is required that each ship shall carry boats sufficient to accommodate all persons on board, either the total number or the certified number, whichever is the larger. The number of davits is made to depend on the length of the ship. The requirements of number of davits and of cubic capacity of boats are given in a table advancing in steps from 100 feet to 1,030 feet. Thus a ship 100 feet long must have two davits, two boats and 980 cubic feet capacity in those boats; a ship 995 feet long must have 30 davits, 20 boats and 48,750 cubic feet capacity. Small ships have no difficulty in meeting requirements, but the difficulty increases with the length of the ship because the possible passenger accommodation increases in some sort of relation to the displacement, and that increases with the cube of the length. A certain table of particulars of boats gives for a 30-foot boat the capacity 607 cubic feet and assigns 60 persons to such a boat. Applying this as a unit to a ship 995 feet long there would be required 80 lifeboats. Thirty of these boats can be under davits, leaving 50 to be otherwise provided. The rules allow some or all of the boats not under davits to be collapsible boats; the Board of Trade is given large discretion and may allow the use of life rafts.

Seven classes of boats are described; four classes are real boats, i. e., (1) open boats with internal buoyancy, (2) open boats with internal and external buoyancy, (3) open boats without special provision for buoyancy, and (4) pontoon boats with fixed bulwarks. Internal buoyancy is provided by cans of copper or yellow metal, stowed under thwarts and side seats. External buoyancy is given by a band of solid cork outside the boat. The object of buoyancy is to give a reserve of buoyancy when the boat is flooded. The plain open boat has certain advantages from its lightness and handiness; it is supplied only to cargo ships having accommodations for all the crew on each side of the ship.

These three classes of open boats and their properties are well known by seamen. Properly constructed they are able boats and can make long voyages. A certain master seaman to the knowledge of the writer made a voyage of 1,200 miles in a ship's boat to find help for the crew of a ship wrecked in the Pacific Ocean.

Now we come to the question of the use of pontoon boats, which have a lower body or pontoon decked once above the waterline. To keep waves off the pontoon and to protect the passengers, there are bulwarks above the pontoon. If given sufficient strength, the bulwarks may serve these purposes, but they are not an integral part of the boat; in some types of boats they can be folded down.

The lower body or pontoon supplies the buoyancy, being closed and watertight; more buoyancy can be provided, and so more passengers may be assigned. Advocates of such boats claim correctly that the buoyancy of the pontoon ensures the life of the boat; unfortunately, the pontoon introduces certain characteristics that are not advantageous for the safety of passengers. This condition comes from the fact that passengers and equipment must be carried above the deck with a higher center of gravity; and, further, free water that may break over the bulwarks is more dangerous than it would be in the bottom of an open boat.

Mention has been made of a pontoon boat with fixed bulwarks; it is considered to be a good boat with ample stability when free from water, and giving fair protection to the passengers. It is said to be rarely supplied to passenger boats because it is at least as troublesome to carry as an open boat. The comparison of open and pontoon boats is brought out in the report of the Committee on Boats and Davits. Intact, both boats can carry full load and have sufficient stability; when partly swamped, the open boat with buoyancy cans has a fair stability; the pontoon boat has none, and is liable to capsize unless it has good relief valves to clear the water inside of bulwarks. When full of water, the open boat has very little stability; the pontoon boat has no stability until some of the water is spilled over the gunwale. There is great danger that the passengers will be spilled at the same time. The boat free from water and passengers may right itself.

In an attempt to meet the requirements that steamers shall carry boats enough for all persons, passengers and crew, boats with collapsible bulwarks have been introduced. With the bulwark down they can be stowed in tiers and save deck room. Three types are described by the author: (1) an open boat with buoyancy cans for buoyancy, (2) a pontoon boat with flush deck, and (3) a pontoon with a so-called well deck.

The open boat with the bulwarks intact is nearly as good when tested in quiet water as the regular open boat with inside buoyancy. The pontoon boats are much like the pontoon boat already described. The bulwarks amidships are made of wood, and when erect are held in place by the thwarts. At the bow and stern the bulwarks are made of painted canvas. The author shows such a boat carrying 54 persons counted as well as may be from the photograph, some seated, some standing. They do not appear to be uncomfortable with the boat as shown in a dead calm. The comparison with a standard lifeboat, which is a real little ship, is certainly not to the advantage of the substitute.

Attempts have been made to improve the collapsible boat by making the bulwarks of wood all the way round. Such boats are doubtless better, but they are not good. To the writer, a fisherman's dory looks better, and it stows closer.

The author shows a design of nested boats by Captain P. D. Murray. They are of three sizes, the smaller ones being stowed inside in succession. The larger boats have hinged thwarts and there are other devices to facilitate stowing. They appear to be real boats, though probably not so good as the standard.

Some attempt has been made to provide ships with one or more motor lifeboats usually provided with a cabin. If it were possible to provide enough motor boats and to

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handle them when needed, a great advantage would be gained. Even a few motor boats to guide, assist or tow rowing boats would be advantageous.

The author gives an excellent statement of various kinds of timber for boats, how timber should be cured and worked. He also goes into details of construction with drawings and instructions for inspection. There are over a hundred pages of such matter on rowing boats and considerable on power boats. He vouches for boats built of mahogany that have lasted more than twenty years. He deals also with metal boats, how they should be constructed and inspected in service; he reflects the prejudice against metal boats found among seamen. To a landsman it looks as though a well made and guarded metal boat should last forever, though, of course, galvanized iron as used for that purpose is known to be untrustworthy.

It is not sufficient to have lifeboats on a ship; there must be adequate provision for launching them full of passengers in an emergency. Boats carried under davits are ready for use. There are, of course, the chances of difficulty in lowering and disengaging when waterborne. Various devices are shown for these purposes; some are ingenious and meritorious, but it is not certain that they are better than accepted forms in the hands of trained men. However, trained men in sufficient number for a large passenger ship are difficult to provide.

When boats are too numerous to be carried under davits, some method of handling must be provided. There are a number of patent davits that can launch boat after boat. We can scarcely complain that time is needed for such service, especially when they are worked by hand. A real difficulty is that all are more or less complicated and require a trained crew for operation. On some large passenger ships the problem is attacked boldly by providing power gear for handling the boats and training crews to man the gear.

In an appendix the author deals briefly with life rafts and various buoyant apparatus.

The Sumner Line

REVIEWED BY C. H. PEABODY, DR. ENG.

THE SUMNER LINE OR LINE OF POSITION AS AN AID TO NAVIGATION. By George C. Comstock. Size, 4 by 6 inches. Pages, 70. Illustrations, 6. Folding plates, 3. New York, 1919: John Wiley & Sons, Inc. Price, $1.25.

If the navigator at his noon observation finds the sun directly overhead, he can find the location of his ship with ease and certainty, because the Nautical Almanac or the (Ephemim) provides ready determination of the location of the sun for any given time. Suppose that instead of having the sun directly overhead, the observation gives an altitude above the horizon as eighty-nine degrees, that is, the sun is one degree from the zenith. The navigator, as before, finds the sun's location and he knows that his ship is sixty sea miles from that position. If he takes the sun's location as a center and draws a circle with a radius of sixty miles, he knows that his ship is somewhere on that circle. If the altitude is some other angle, say eighty degrees, then the same conditions hold and the ship is six hundred miles from the same location.

In order to use this information—that is, in order to draw the Sumner line of position, the navigator must have some elementary knowledge of practical astronomy; but the author asserts that the method is easy and simple in practice, especially with the aid of certain tables issued by the Navy Department. The author presents the actual operations of this method with illustrative examples, clearly and succinctly. For those who desire to know the rational development of the method, the author gives the proper demonstrations separately.

This method can as readily be used for observation on stars; in fact, it is especially adapted to that purpose, since it should be easy to select a star with convenient altitudes, and a star does not wander around the heavens as the sun does.

Evening Courses in Ship Design and Marine Engineering at Brooklyn Polytechnic Institute

SEVERAL special evening courses which will be of interest to men connected with the shipbuilding and shipping industries have been arranged for the coming winter at the Polytechnic Institute, Brooklyn, N. Y. These courses cover ship drawing and design, yacht design and marine engineering. They will begin early in October, and registration may be made any time between September 15 and October 1, by addressing the Director of the Evening Department, Polytechnic Institute, 99 Livingston street, Brooklyn, N. Y.

The course in ship drawing and design will consist of a series of lectures and exercises in calculations and drawing, illustrative of the work done in the hull design department of a shipyard. This course is given by Mr. F. B. Webster, editor of MARINE ENGINEERING and the SHIPBUILDING CYCLOPEDIA. Mr. Webster is a graduate of the Department of Naval Architecture and Marine Engineering of the Massachusetts Institute of Technology, and has had many years of practical experience in hull and engine work as well as designing experience in both lines in various shipyards. He was formerly engaged in research work in the Bureau of Construction and Repair, Navy Department, Washington, D. C., and during the war was naval architect for the concrete ship section of the Emergency Fleet Corporation.

The course in yacht design will deal with the design of the hull of a vessel, the drafting and fairing of lines, and the calculations of the various properties of the floating body from the lines. While a small yacht hull is used in the course, the principles of theoretical naval architecture there exemplified apply to a ship of any size, and the instruction will be of value to all those engaged in any field of marine work.

Two courses are offered in marine engineering. The object of the first is to furnish special training in marine engineering to men already possessing technical knowledge in steam and mechanical engineering. This course will cover engines, boilers, auxiliaries and piping. The second course is planned for men now holding non-technical positions in shipbuilding, ship repair, and marine transportation companies, and for others without special training in engineering lines who wish to gain a general knowledge of marine engineering as an aid to them in their work.

For information regarding the requirements for applicants for these courses and the hours and fees, requests should be sent to the Director of the Evening Department of the Institute.

The course starts with lectures and study assignments on the structural arrangements of a steel ship, and while these are being carried on, practice is also given in the drawing and tracing of typical details of ship construction. This is followed by a study of the rules of the classification societies, and the assignment of a special problem to each student on the design of a particular type and size of ship. Finally the method of basic design of a vessel is explained.

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Questions and Answers for Marine Engineers

Inquiries of General Interest Regarding Marine Engineering and Shipbuilding Will Be Answered in this Department

This department is maintained for the service of practical marine engineers, draftsmen and shipbuilders. All inquiries should bear the name and address of the writer. Anonymous communications will not be considered. The identity of the writer, however, will not be disclosed unless the editor is given permission to do so.

Standing Rigging for Signal Masts

Q. (1054).—Kindly inform me how the standing rigging is determined on ships with unusually high rigging, as scout cruisers, destroyers, etc., without cargo booms. T. R. P.

A. (1054).—A mast is subjected to complex forces which make it difficult to determine the stress coming upon the rigging. However, we may consider that the mast is not fixed at the deck, but acts in the nature of a column free at the ends and of length equal to the distance from the deck to the point of attachment of the lower rigging. If, then, the effect of the upper rigging is neglected, the forces and their moments about the foot of the mast can be approximated. The principal forces will be as follows:

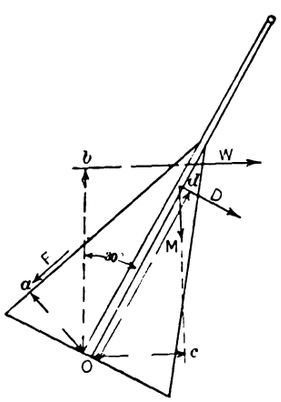

Diagram of Forces

Fore and aft forces to be taken care of by the stays.

Dynamic force due to the vessel's pitching.

Wind force due to a head wind of high velocity.

Static force due to the mast's weight at the maximum angle of pitch.

Athwartship forces provided for by the shrouds.

Dynamic force due to the vessel's rolling.

Wind force due to wind at high velocity.

Static force due to weight of mast at extreme angle of roll.

The above forces, with the exception of the mast's weight, will have to be approximated by assuming an angle of pitch and time of pitching, also the same with rolling and, furthermore, a maximum wind velocity.

The dynamic force of pitching would be:

$$F = \frac{W \pi^2 l \Theta}{g t^2},$$

in which t is the time of a single pitch, l is the distance of the center of gravity of the mast from the axis of pitch, and Θ is the maximum angle of pitch. The same formula will also serve for rolling. A formula giving the wind resistance of a cylinder can be used to find the wind force on the mast.

The above forces will produce a moment about the foot of the mast which the resisting moment of the rigging must equal and from that the necessary force in the rigging may be computed. The figure shows the athwartship forces and their moment arms with the vessel at 30 degrees roll, where

oa = moment arm of force in shrouds (F).
ob = moment arm of wind force (W).
oc = moment arm of mast weight (M).
od = moment arm of dynamic force (D).

An example has been worked out by this method in "Strength of Ships" (Longmans-Green) by A. J. Murray. Another distinct calculation is made sometimes for the stress in the shrouds, if the vessel is on her beam ends (inclined 90 degrees).

Size of Lifeboat Davit

Q. (1055).—Please indicate the method of finding the diameter of a solid wrought steel davit for a lifeboat of the following dimensions: 24 feet by 7 feet 9 inches by 3 feet 4 inches. I note that the United States Steamboat Inspection Service does not directly specify the diameter, but makes the requirement that the davit must be strong enough to lower the boat when the vessel has a list of 15 degrees. What would be the stress in the davit when vessel is upright, also when at a 15-degree list?

A. (1055).—If we take the height and radius of the davit as given in the figure, the diameter of davit in way

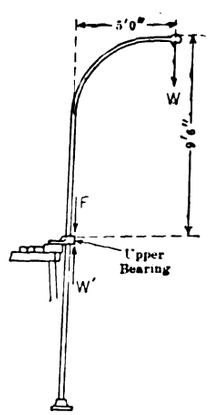

Fig. 1

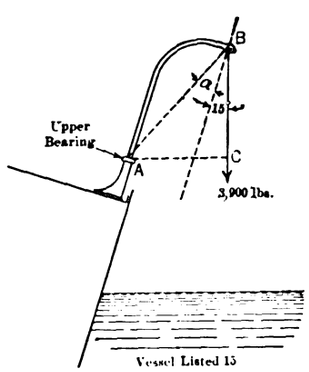

Fig. 2

of its upper bearing can readily be obtained from either the American Bureau or Lloyds Rules.

$$d = \sqrt[3]{\frac{L \times B \times D\,(H + 4S)}{C}} \text{ inches (Lloyds)},$$

where L, B and D are the length, breadth and depth of the boat, respectively, in feet.

H = height of davit, in feet, above its upper bearing.
S = radius or outreach of davit in feet.

The value of C depends upon whether the davit is to be strong enough to lower the boat and several men or the boat and its entire complement. It also depends upon what material the davit is made of. If we consider that in this case the davit is forged of wrought steel of about 65,000 pounds per square inch tensile strength and is designed to lower the boat and full complement, a constant $C = 99$ is required, so that we have:

$$d = \sqrt[3]{\frac{24.0 \times 7.75 \times 3.33\,(9.5 + 4 \times 5.0)}{99}} = 5.70 \text{ inches, or about } 5\tfrac{3}{4} \text{ inches.}$$

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In order to obtain the stress we may approximate the weight of boat equipment and complement as 7,800 pounds. Thus a load of 3,900 pounds, with the vessel upright, can be resolved into a downward force, $F = W$, acting at the center of the davit section in way of the bearing and a couple whose moment arm is 5 feet. This force and couple will then produce:

Bending Moment = 3,900 × 5 = 19,500 foot-pounds.
Direct Load = 3,900 pounds.

The tensile and compressive stress due to the bending moment will equal:

$$f_b = \frac{My}{I} = \frac{19{,}500 \times 12 \times 2.88}{53.6} = 12{,}580 \text{ pounds per square inch.}$$

$$I = \frac{\pi d^4}{64} = \frac{3.142 \times 1{,}093}{64} = 53.6.$$

The compressive stress due to the direct force will be:

$$f = \frac{P}{A} = \frac{3{,}900}{25.97} = 150 \text{ pounds per square inch.}$$

Hence the resultant of these stresses will be:

Compression = 12,580 + 150 = 12,730 pounds per square inch.
Tension = 12,580 − 150 = 12,430 pounds per square inch.

To find the increased stress due to a 15-degree list (see Fig. 2), it will be necessary to find moment arm AC, which can be obtained by the following steps:

$$AB = \sqrt{5.0^2 + 9.5^2} = 10.75 \text{ feet.}$$

$$\sin \alpha = \frac{5}{10.75} = .465.$$

$$\alpha = 27^\circ\ 43'.$$

Angle $ABC = 27^\circ\ 43' + 15^\circ\ 0' = 42^\circ\ 43'$.

$$AC = 10.75 \times \sin 42^\circ\ 43' = 10.75 \times .6784 = 7.29 \text{ feet.}$$

If a moment arm of 7.29 feet is replaced for that of 5 feet in the preceding work, we will obtain:

Bending Moment = 7.29 × 3,900 = 28,500 foot-pounds.

$$f_b = \frac{28{,}500 \times 12 \times 2.88}{53.6} = 18{,}370 \text{ pounds per square inch.}$$

Hence the stress due to bending is nearly 50 percent greater with vessel listed than when upright. With the vessel listed there would furthermore be a stress of shearing on the davit cross-section, besides that of tension and compression, which we have not mentioned.

Repairs at Dry-Docking

Q. (1056).—Please list the repairs ordinarily undertaken while a vessel is in dry dock, and also give the length of time between dockings.

A. (1056).—The length of time between dry-dockings depends upon many factors, such as the port repair facilities, time available, the practice of the operating company, etc. Some companies make it a custom to dry dock a vessel every six months, others at a much longer interval. The United States Shipping Board has tried to average about eight months between dockings. It is wise to dry dock a new vessel within six months of launching.

Besides the managing company's shore representative, a surveyor from the registration society, and possibly an inspector from the United States Steamboat Inspection Service, who have been notified in advance of the docking, will make an inspection of the vessel and require or suggest various repairs, some of which are noted here. If the shell plating is indented perceptibly, these plates should be located, and if not faired at this time a record should be kept of same so as to place the responsibility.

If it be a new vessel it will be advisable to remove the propeller, fair water cone and harden up the propeller nuts (which may take up a quarter of a turn in the case of a new wheel). If time permits, find the pitch of the propeller, doing this for all blades. Examine and harden up blade nuts of separable blade propeller, if necessary. Measure the amount of clearance in the stern bearing (i. e., the amount the shaft is down). The lignum vitae is bored for a clearance of about 1/16 inch and the classification societies require that this bearing be rewooded when this clearance as shown by a tapered wooden wedge has increased to about 5/16 inch.

Tail Shaft and Rudder Gudgeon Bearings

If the tail shaft has two separate bronze liners, or one at the stern bearing near the propeller and one in way of the stuffing box at the aft peak bulkhead, the classification societies will require that the shaft be drawn clear of the stern tube for survey every two years. This consists in tapping the liners lightly to see whether they are loose, also to examine the shaft between the liners for cracks or undue corrosion. The fit of the propeller on the tail shaft should also be examined. This must bear at the large end of the taper; the small end of the shaft's taper can be .005 inch smaller in diameter than the hole in the hub for a large propeller. The fit and bearing of the key should also be checked, as, if local, the tail shaft may crack; looseness will, of course, cause vibration. Some firms, with the separate liner type of tail shaft, red lead the shaft between liners and cover it with canvas and a layer of rope marline coated with red lead. If the bronze liners are continuous, i. e., in separate pieces but soldered to each other at the joints, the societies call for the tail shaft survey every three years.

Further repairs directly under the engineering department would be to examine and grind in, if necessary, all sea valves, clear their strainers and repack the tail shaft gland.

The rudder gudgeon pin or pintle bearings should be examined for proper bearing and clearance; when new, the latter may be about 3/32 inch on the diameter of the pin for a fair sized cargo vessel. The gudgeon pin bearings are either lignum-vitae or bronze, although of late soft steel has been used.

Riveting, Scraping and Painting

It is advisable where possible when docking to have all ballast tanks full, as any leaks will then readily show up. Any tanks that require cleaning or rivet driving may be drained, although with steam up they can be more quickly pumped out, and the writer would advise that steam be kept up, as the ship can be listed or trimmed, if desired, and is under control. All leaky rivets (and most war emergency ships have enough of these) will be calked, hardened up or re-driven as required by the classification society surveyor and the work when completed passed by him.

Before coming off the dry dock it is customary to wire-brush or scrape the shell plating and apply one coat of anti-corrosive, together with a coat of anti-fouling, below the light waterline and one of boot-topping above. If the time in dock permits, it is a good plan to run out all the anchor chain, wire-brush or scale it, and paint it with fish oil.

If the important repairs, condition of the hull, condition and clearance of tail shaft and rudder gudgeon bearings and any other important data are noted in the log books, much money will be saved in the operation of the vessel by avoiding the needless repetition of certain repairs, and a better report can be turned into the managing company.

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PERSONAL MENTION

E. L. WHITNEY was recently elected president of the Kelly Drydock & Shipbuilding Company, of Mobile, Ala.

DAVID C. YOUNG, who until recently was general manager of the Hanlon Dry Dock and Shipbuilding Company, has been placed in charge of the Seattle office of the Martin-Gardner Survey Board for the inspection of Shipping Board tonnage.

ALFRED H. HAAG, formerly chief constructor for the United States Shipping Board Emergency Fleet Corporation, has opened offices at 406-408 Water Street, Baltimore, Md., as a consulting naval architect and marine surveyor. Mr. Haag is considered to be one of our best authorities on ships' rigging and cargo handling gear, a subject of very great importance to the economical operation of the merchant marine.

Alfred H. Haag

The Atlantic, Gulf and Pacific Steamship Company, which has a fleet of ten vessels aggregating about 90,000 deadweight tons, has retained Mr. Haag as naval architect for their line. The care of these vessels, which range from 7,400 to 11,400 tons deadweight capacity, is quite an assignment in itself and we feel that Mr. Haag's success in his new location is assured.

Slightly more than twenty years ago Mr. Haag began work, at the age of fifteen years, in the offices of Cary Smith & Barbey (later Cary Smith & Ferris), naval architects, New York, remaining with them five years. The following five years he served in the drawing rooms of the following well-known naval architects: H. C. Wintringham, Henry J. Gielow, and Tams, Lemoine & Crane. While with the latter firm he received an offer from the War Department in Washington in the ship design branch of the Quartermaster General's office, after which he accepted an appointment with the Navy Department, first serving in the drawing room of the new design section and later in the scientific department. While with the Navy Department he received an offer from the Newport News Shipbuilding & Dry Dock Company, in the engineering section, which he accepted, remaining with them eight years. He left this company just prior to this country's entering the war to go into business for himself in Philadelphia. He had hardly started his new business when he received a call for his services from the United States Shipping Board, which was then organizing, and was appointed to the position of chief draftsman at the home office of the United States Shipping Board, Emergency Fleet Corporation. Later he was promoted to the position of assistant chief constructor and finally to the position of chief constructor.

Mr. Haag is a member of the American Society of Marine Draftsmen, having held the office of national president for the past two years. He is a member of the Society of Naval Architects and Marine Engineers and consulting editor of the *Shipbuilding Cyclopedia*.

WILLIAM H. TODD, president of the Todd Shipyards Corporation, New York, in recognition of his valuable service during the war, was awarded the degree of Doctor of Laws by the Most Reverend Patrick J. Hayes, archbishop of the diocese of New York, at the commencement exercises of Manhattan College held in Carnegie Hall, New York City, June 16. Brother Thomas, dean of the college, in announcing the award, said:

William H. Todd

"The honorary degree of Doctor of Laws is conferred on a leading citizen of Brooklyn; a man of constructive genius, who, starting life as a boy-mechanic, in his early twenties stood first on the civil service list of the Navy Yard as a master shipbuilder. Later in private life, beginning as foreman, he rose in a decade to the presidency and then to the ownership of the largest ship repair yard in the world.

"He is today recognized as the premier shipbuilder in the United States. A leader of men, employing upwards of twenty thousand—every one of whom knows and loves him—he is described by one of the great captains of industry (Charles H. Schwab) as 'a human dynamo; a man among men, who does things, and whose life is a record of achievements.' He is a philanthropist and a patriot."

GEORGE GILLIS SHARP, consulting naval architect and marine surveyor, has opened offices at the Hudson Terminal building, 30 Church street, New York. Mr. Sharp, the late chief surveyor of the American Bureau of Shipping, is a graduate of Glasgow Technical College, where many of our American naval constructors have received their post-graduate courses. His practical training was acquired at the D. & W. Henderson Company, the oldest of the famous Clyde shipbuilding companies. Mr. Sharp came to America to take the position of chief draftsman with the Eastern Shipbuilding Company, which built the Great Northern liners *Minnesota* and *Dakota*, a noteworthy event for his début into American shipbuilding. After the completion of these marine giants, Mr. Sharp entered the employ of the Harlan & Hollingsworth plant as chief draftsman, and from there went to the Pacific Coast to take the position of chief draftsman in the Seattle Construction & Dry

George G. Sharp

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Dock Company, Seattle, Wash., thus rounding out his American shipbuilding experience on both coasts.

In 1913, Mr. Sharp returned to his former position as chief draftsman of the Harlan & Hollingsworth Company, which was in itself an endorsement of his former work, and remained there until 1913, when he went with the American Bureau of Shipping as deputy chief surveyor. With the outbreak of the war, Mr. Sharp became chief surveyor of the bureau, and under his technical guidance the bureau expanded in leaps and bounds, until it reached the state it is in today, with offices in all the principal American ports and many foreign ports such as Hong Kong, Buenos Aires, Havana, etc. As chief surveyor of the American Bureau of Shipping, Mr. Sharp built up an organization that is world wide in its habitat and activities and international in its importance—an organization that during a war of unprecedented marine malevolence and destruction helped create out of a chaos of cross purposes and political trickery the second greatest mercantile marine sailing the seven seas today.

C. STEINDORFF has been elected vice-president and treasurer of the Brooks Steamship Company, New York, to succeed F. Bradley Cox, resigned.

CHARLES O. LENZ, consulting engineer, New York City, has been appointed one of the consulting engineers for the Foundation Company of New York City.

FRANK BURKE, assistant chief of the Bureau of Investigation of the Department of Justice, has been appointed assistant to Chairman Benson of the Shipping Board.

W. B. KEENE, who has been district director of the Shipping Board in the Gulf district, has been appointed assistant director of operations in the general office at Washington.

LESTER C. NEFF, former district agent of the Shipping Board, Galveston, Tex., has resigned to become assistant general manager of the Export Steamship Company, Inc., Baltimore, Md. He is succeeded in the operating department of the Shipping Board by C. H. Marshall, whose offices will be at New Orleans.

BRIGADIER GENERAL FRANK T. HINES recently resigned from the army to become general manager of the Baltic Steamship Company. During the war, General Hines made possible the rapid handling of men and supplies of the American Expeditionary Forces with the development of terminals, which he was able to do as head of the Transportation Service of the Quartermaster's Corps.

HARRIS LIVERMORE, senior operating officer of Livermore, Dearborn & Company, Inc., and likewise president of the Shawmut Steamship Company, New York, will become president of the United American Lines, Inc. Henry Dearborn, son of the late George S. Dearborn, of the Hawaiian Steamship Company, now the senior vice-president of Livermore, Dearborn & Company, Inc., will become vice-president of the United American Lines, Inc.

BRIGADIER GENERAL WILLIAM D. CONNOR will succeed Brigadier General F. T. Hines as chief of the Inland Waterways Division of the War Department. General Connor is particularly familiar with Mississippi River conditions. During the war he served as chief of staff, Headquarters Service and Supplies, under General Harbord in France. After General Pershing returned to the United States he became general in command of the American forces in France.

J. F. M. STEWART, Toronto, Can., director of the Halifax Shipyards, Ltd., Halifax, Nova Scotia, has been elected a director of the Dominion Steel Corporation of Toronto, Canada.

ROMEO MORRISSETTE, until recently connected with the National Shipbuilding Corporation, Three Rivers, Quebec, has entered private practice as a consulting engineer in that city.

R. A. DEAN, assistant counsel for the Shipping Board, and Judge Goff, general counsel for the Emergency Fleet Corporation, have been elected trustees of the Emergency Fleet Corporation.

CAPTAIN M. S. HARLOE, of the Division of Operations of the Shipping Board, is at the present time engaged in establishing Shipping Board agencies in the important centers of the Orient.

A. J. FREY, director of construction and repairs of the Emergency Fleet Corporation, has resigned to become manager of the Los Angeles Steamship Company. He was formerly connected with the old Pacific Mail Steamship Company.

CHRISTIAN J. BECK, formerly manager of the freight traffic department of the Hamburg-American Line, and more recently general manager of the Kerr Steamship Company, has become the head of the executive personnel of the United American Lines, Inc.

JOHN QUINN, district director of the Shipping Board at Boston, has succeeded W. B. Keene as director in the Gulf district, and P. H. Lacey, of the Operating Department, Washington, is to succeed Mr. Quinn as acting district director for the New England section.

JOSEPH STULL, JR., formerly general superintendent of the Pusey & Jones Gloucester, Pa., yard, has been appointed assistant manager in charge of the ship construction division of the United States Shipping Board Emergency Fleet Corporation, with headquarters in Philadelphia.

DUDLEY W. BURCHARD, for the last two years district agent of the operating division of the Shipping Board at Puget Sound, has been appointed head of the newly created North Pacific District of the Shipping Board Operating Division, with headquarters at Puget Sound, Wash. Territory included in this district will be Puget Sound, Portland, Oregon, and the Columbia River terminals. This move marks the separation of the operation of the Shipping Board in Puget Sound from the San Francisco office.

CAPTAIN J. HOWARD PAYNE has recently been appointed supervisor of the Shipping Board's recruiting service for the Pacific Coast, with headquarters at Seattle. For twelve years Captain Payne was in the service of the Puget Sound Navigation Company. During the war he became commander of the merchant marine training ship *Chippewa*. In the early part of 1918 he was appointed to the Sea Service Bureau of the Shipping Board in Seattle. It was through his success in this position that he has been appointed supervisor of the recruiting service, which comprises the officers' schools in navigation and marine engineering, the Sea Service Bureau and the merchant marine training station on the coast.

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Shipbuilding and General Marine News

Contracts for New Ships — Shipyard Improvements — Engineering Projects—Improved Appliances—Personal Items

PRICES FOR U. S. VESSELS MADE PUBLIC BY SHIPPING BOARD

Craft to be Disposed of Number 1,502, and Prices Named are Generally Considered Too High—Payments Spread Over Twelve Years

In a formal announcement the Shipping Board's programme for the sale of 1,502 steel vessels, built for and owned by the Government, has been made public. The prices named for the ships range from $160 to $185 per deadweight ton, and no prices are quoted on wooden vessels. Payment of 10 percent cash, with the balance spread over a twelve-year period, are the terms on which the vessels will be sold, and there is considerable doubt among shipping men as to the response that will be made to the call for bids at the prices named, even when the easy terms of payment and the allowed mark-off for depreciation are considered. The fact that two of the 10,400-ton freigters built for the Skinner & Eddy Corporation for its own use recently sold for $144 a ton, and that vessels of a similar type can be purchased in England at less than $100 a ton, leads to the conclusion that the present prices asked by the Government are more in the nature of feeling out the market than a real indication of what the Shipping Board actually expects to get. It is generally believed that these prices will have to be revised downward before the great bulk of the tonnage is disposed of.

The Board's statement of its sales programme follows:

"The Congress of the United States has enacted and the President has approved, under date of June 5, 1920, the new Merchant Marine Act.

"Under the provisions of this act the Shipping Board is charged with the duty of adopting and executing a ship sales policy that will in fact establish the merchant marine of the United States upon a sound operating and financial basis.

"Pursuant to this duty the Shipping Board, after a careful survey of the current operating revenue, costs of operation, competitive conditions now existing and which will exist, financial and the general economic situation, offers to the public the following plan of the ship sales:

"Ten percent of the purchase price in cash upon delivery of the vessels; 5 percent in six months thereafter; 5 percent in twelve months thereafter; 5 percent in eighteen months thereafter; 5 percent in twenty-four months thereafter.

"The balance of 70 percent in equal semi-annual instalments over a period of ten years; deferred payments to carry interest at the rate of 5 percent per annum.

"All revenues derived from operations are to be deposited in a controlled or supervised account, and the instalments above provided for, except initial payments, may be paid therefrom.

"The purchaser shall be permitted to take from such proceeds of operation, after the current instalments are paid, not exceeding 15 per centum, upon paid-up instalments, as a dividend upon such investment to be distributed to stockholders of the purchasing corporations as it (the corporation) shall determine.

"Upon payment of 50 per centum of the purchase price the buyer is to execute a preferred mortgage to the Board, and thereafter the operation of the vessel is released from the supervision and control of the Board, except as to mantaining berth and route.

"The foregoing terms of sale are applicable only to new steel tonnage.

"The Board has established as minimum prices those hereinafter set forth.

"The Board will entertain bids on the various types, sizes and classes of the vessels hereinafter described, after same have been properly advertised and appraised. As is provided the price offered shall not be lower than the said minimum price. The Board at all times reserves the right to reject any and all bids.

"Types and classes of vessels, with minimum prices:

"Vessels built on Great Lakes for ocean service, coal burners, $160 per ton; oil burners, $170.

"Submarine Boat Corporation type, 5,350 tons, coal, $160; oil, $170.

"Hog Island type (American International Shipbuilding Corporation), 7,800 tons, coal, $175; oil, $185.

"Skinner & Eddy type, 8,800 tons, coal, $175; oil, $180.

"Skinner & Eddy type, 9,600-10,076 tons, and all other vessels over 10,000 tons, excepting combination cargo and passenger vessels, oil tankers and refrigerator vessels, coal, $175; oil, $185."

"The foregoing prices shall be subject to a deduction for depreciation at the rate of 6 per centum per annum for the second year of the vessel's age, and five per centum for every year thereafter to date of purchase, depreciation to be allowed for whole months only, and up to the estimated date for delivery.

"In every case the Board will insist upon full and satisfactory evidence of the financial ability of the buyer to carry out his contract and meet his financial obligations as they become due. Proof as to the nationality of the purchaser in compliance with the Merchant Marine Act, 1920, will also be insisted upon.

"Upon application the Board will furnish the names, the tonnage and general specifications of the vessels for sale.

(Signed) "United States Shipping Board,

"W. S. Benson, Chairman."

Of the 1,502 vessels to be offered 1,394 are cargo vessels, 27 are cargo and passenger vessels, 63 tankers, 15 refrigerators and 3 transports.

AMERICAN SHIPS LEAD

Interesting Figures of Ocean Commerce for Six Months of 1920

A survey of vessels entering and clearing in the foreign trade with cargo at United States customs districts, covering the first six months of the calendar year 1920, shows some very interesting features in the relations of domestic and foreign bottoms engaged in the export and import trade with the United States.

A total of 15,558 vessels of 86,031,700 deadweight tons have entered and cleared United States ports in the six months ending June 30, carrying 37,398,184 long tons of cargo. Vessels under American registry to the number of 9,550 (61.4 percent of the total vessels), aggregating 51,534,620 deadweight tons (59.3 percent of the total tonnage), carried 22,724,217 long tons of cargo (60.8 percent of the total cargo carried). The American vessels carried 44.1 percent of capacity load and the foreign vessels 41.5 percent; the average for all flags being 43 percent.

The distribution between exports and imports shows that while many of the American vessels are carrying return cargoes to United States ports, the foreign vessels are to a large extent entering in ballast and clearing with more cargo in proportion to the number and tonnage of vessels employed.

In export trade 8,114 vessels, aggregating 43,754,487 deadweight tons, carried 22,723,165 long tons of cargo. Of vessels

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clearing in export trade under American registry 4,095 vessels, of 25,328,050 deadweight tons, carried 11,591,446 long tons of cargo; that is 61.6 percent of the total number of all vessels employed in export and 57.9 percent of the deadweight tonnage were under the American flag, and 51 percent of the cargoes exported were carried in American bottoms.

In the imports, American vessels, numbering 4,555, aggregating 26,206,570 deadweight tons, carried 11,132,741 long tons of cargo. This was 61.2 percent of the total number of all vessels entering United States ports with cargo representing 60.7 of the total deadweight and carrying 75.9 percent of the commodities imported.

The average export load of all vessels was 2,800 long tons, of 51.9 percent of the deadweight employed. American vessels carried an average of 2,320 tons per vessel, or 45.7 percent of deadweight, while foreign vessels averaged 3,248 long tons, or 60.4 percent of deadweight. The imports averaged 1,972 long tons per vessel, or 33.9 percent of deadweight employed. American vessels averaged in imports 2,444 long tons, or 42.1 percent of deadweight per vessel, while foreign vessels only averaged 1,226 long tons, or 20.1 percent of deadweight per vessel.

In the export trade American vessels employed 2.19 deadweight tons of vessels to transport 1 long ton of cargo, while the foreign vessels utilized 1.93 deadweight tons of vessel for each long ton of cargo carried. This situation was reversed in the import trade, as American vessels employed 2.35 deadweight tons for each ton of cargo, while the foreign vessels used 4.79 deadweight tons for each long ton of cargo entering American ports.

The total tonnage employed in both export and import trade by all flags was 2.32 deadweight tons of ship for each long ton of cargo carried.

A comparison of reports of the Bureau of Foreign and Domestic Commerce for the calendar year 1919, based on the net tonnage of all vessels clearing with cargo in export trade, shows that 42 percent of the net tonnage was under the American flag and 58 percent under foreign. Of vessels entering in import trade for the same year, 51.1 percent were American and 48.9 percent were foreign.

No German Money in U. S. Mail Company

Admiral Benson has stated that the contract between the United States Mail Steamship Company and the North German Lloyd contemplates the renting of the piers and other facilities at Bremen with the employment of Germans on salaries as agents for the company. The Germans will not be allowed financial interest in the company.

Most of the ex-German liners chartered to the United States Mail by the Shipping Board will be delivered by the end of the year, and services will be inaugurated as soon as the reconditioning of the vessels can be completed.

HOG ISLAND YARD TO BE SOLD BY SHIPPING BOARD

Largest Shipbuilding Plant In the World To Be Disposed of—Has Turned Out 122 First Class Vessels

The enormous plant constructed by the American International Shipbuilding Corporation for the Shipping Board Emergency Fleet Corporation is to be sold on bids to be received by the Sales Division of the Shipping Board up to September 20. This announcement disposes of the flock of rumors which have been circulated regarding the disposition of the big plant when its work for the Government was ended, and leaves for an answer the question as to what interests are big enough to take over the establishment and make profitable use of it.

Under the war programme 122 vessels were constructed for the account of the Shipping Board, and have proved to be some of the best built for the Government.

The Board stated that it would give possession of the plant on October 1 upon completion of the present building programme. Title will remain with the Emergency Fleet Corporation until it is completely paid for by the purchaser.

Hog Island has an area of 946 acres, water frontage of two miles, twenty-seven warehouses, eighty-two miles of railroad tracks, twenty-one miles of roads, fifty shipbuilding ways, sewerage and drainage, seven steamship piers, administration, record and telephone buildings, shop buildings adaptable to terminal uses, power, air, electric, steam, water and oil lines, classification yards and complete fire protection.

The four-story concrete warehouses and the twenty-six wooden warehouses, with a total floor area of more than one and three-quarter million square feet, are so designed as to be available as storage bases in a terminal. Each warehouse is served by a railroad track, and has a platform adjoining a street for its entire length.

The total floor space of all buildings, 4,505,000 square feet, is equivalent to 103 acres, of which 24 percent is fireproof.

Each of the piers is equipped with four self-propelling gantry cranes, with sufficient clearance to permit the operation of standard locomotives and cars. In addition each pier is equipped with two locomotive cranes and Pier B with a bridge crane, span of 118 feet and lifting capacity of 100 tons. Between piers there is 266 feet of clear water space, which permits the docking of four ships in each

There are 50 ways, 40 wood, 10 concrete, each equipped with fixed stiff leg derricks. Hog Island also has 10 electrically equipped pumping stations, 75 miles underground cables, 45 miles fiber duct laid in concrete, filtration plant, sewage disposal plant, which with the other appliances, facilities and equipment provides it with the fundamentals for the best arranged and modernly equipped terminal and storage yard in the country.

Sealed bids will be received until 1 P. M., September 20, 1920, by the Supply Sales Division, United States Shipping Board Emergency Fleet Corporation.

Title to the property will remain in the hands of the United States Shipping Board Emergency Fleet Corporation until full purchase price has been paid.

The right to reject any or all bids is reserved.

D. H. Cox Has an Assistant

Daniel H. Cox, secretary-treasurer of the Society of Naval Architects and Engineers, announces that Thomas J. Kain has been appointed as his assistant, and hereafter will be in constant attendance at the society's room, 29 West Thirty-ninth Street. Mr. Kain has assisted for many years in the secretarial duties of this society in a most efficient and faithful manner, and with his long experience should prove of great help to the members. This society is headquarters for the principal marine engineers and naval architects of the country. Its library contains 150,000 volumes and pamphlets on technical subjects. For the benefit of members unable to visit the library in person, lists of references to engineering subjects or technical works, and copies or translations of articles are furnished on request. Engineers and naval architects are to be congratulated upon having such an admirable organization at their disposal.

SHIPPING BOARD SUED

Pusey & Jones Shipyard Case Taken to United States District Court

Differences between Christoffer Hannevig, of the Pusey & Jones Company, and the United States Shipping Board regarding compensation for construction of ships and damages resulting from cancellations of contracts, have been brought into the United States courts through a petition filed in the District Court in Washington by Charles E. Hughes, of counsel for Mr. Hannevig, seeking to restrain the Emergency Fleet Corporation from withholding payment of $7,194,475 authorized by the Shipping Board on March 13 last as "just compensation." The action reveals why the reported sale of the Gloucester, N. J., shipyard to the Baltimore Dry Docks & Shipbuilding Company was not completed.

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THE MARINE EXPOSITION AT CHICAGO, OCTOBER 18-23

Importance of An American Merchant Marine to be Visualized; Shipping Board to Exhibit Largest Metal Map of World Ever Made

"National Marine Week," in conjunction with the great National Marine Exposition at the Grand Central Palace, New York City, under the auspices of The National Marine League, did a great missionary work in bringing home the importance of an American merchant marine adequate to the country's needs. It visualized to the 70,000 visitors at the exposition the economic value to a nation of resources that have produced as fine a fleet as can be found under any flag. It enabled them to understand Jefferson's apothegm, "In shipping all industries meet." "Keep the Flag Flying" is the slogan of the League, and to further this idea a series of Marine Expositions have been planned.

The next exposition will take place at the Coliseum in Chicago during the week of October 18 to 23, 1920. The object of this exposition will be threefold:

First. To focus the attention of the voting population of the Middle West on the great and constantly increasing importance of America's merchant sea power in relation to the maintenance of inland prosperity.

Second. To impress the public of the entire country with the wealth and magnitude of our lake and inland water shipping, to the end that this part of the nation's transportation problem may receive the serious and intelligent attention of both national and State law makers.

Third. To provide a market place where buyer and seller of ships, service and marine equipment may conveniently meet and do business.

The United States Shipping Board will be one of the prominent exhibitors at this exposition. It will have among its exhibits the largest metal map of the world ever made. It will be in bas-relief and will require about two tons of metal. Its measurements will be 15 by 42 feet. Admiral Benson, chairman of the Shipping Board, will open the exposition.

John Barton Payne, former chairman of the United States Shipping Board, has emphasized the importance of inland water transportation in the United States, and points out that the Great Lakes transportation system, important as it is at present, is in its infancy, and that delay in its development will cost producers, shippers and consumers millions of dollars yearly. "The importance of Chicago alone," he says, "not only as a manufacturing and packing center, but also as a clearing house for shippers generally west of Illinois, argues strongly for bringing to the highest possible state of accessibility and efficiency all means of freight transportation." Hon. J. W. Alexander, Secretary of the Department of Commerce, in a recent letter to Mr. P. H. W. Ross, president of The National Marine League, commenting on the National Marine Exposition held in New York City, wrote in part: "I sincerely wish a similar exposition might be held in some of our large cities in the Central West. It would do much to increase the interest of the people in the Central West in our merchant marine. I am losing no opportunity to drive home to our people in the Central West the fact that they are vitally interested in this great question."

UNION PLANT'S BIG DOCK

Bethlehem Corporation's San Francisco Plant Gets Important Addition

The Bethlehem Shipbuilding Corporation, Ltd., announced late in August that the new 12,000-ton floating dry dock at its Union plant, San Francisco Bay, is expected to be ready for full operation on September 1. The dock was purchased, when nearly completed, from the Ames Shipbuilding Company at Seattle, and was towed to San Francisco.

With this dock in position the Union plant—which has docked 2,500 vessels in thirty-two months—will have facilities for docking unrivaled on the Pacific. The new dock is in four sections, each 90 feet long by 126 feet wide. The total length of the dock over the aprons is 421 feet 6 inches.

The Alameda works of the plant also has extensive graving docks, all cut out of solid rock and lined with concrete. One of these is the largest in the world, being 1,020 feet long, 153 feet wide at the top and 86 feet wide at the bottom. A second dock is 750 feet long. This plant also has two large marine railways, and is adding 60,000 square feet to its already large wharfage space, and also 2,500 lineal feet of berths for ships. Its new piers are built with creosoted piling, which resist the ravages of the teredo worm.

The Union plant's complete facilities are the largest on the Pacific Coast, including 75 fireproof buildings with 1,500,000 square feet of floor space, all equipped with modern machinery, and a very large assortment of modern shipbuilding equipment.

A floating dry dock of 2,500 tons capacity, until recently used at the Alameda works, will be removed to the Potero works, giving the latter four floating docks of 23,000 tons combined lifting capacity.

THREE COMPANIES MERGED

Harriman Interests Form Big Steamship Combination

Announcement has been made by W. A. Harriman, president of the American Ship & Commerce Corporation, and senior vice-president of the American-Hawaiian Steamship Company, that his companies have purchased the firm of Livermore, Dearborn & Company, Inc., and will operate the joint fleets and shipping concerns controlled by them. The joint concerns, to be known as the United American Lines, will control ships of about 600,000 aggregate deadweight tonnage. The operating contract which the Kerr Navigation Company has with the American Ship & Commerce Corporation will be canceled under a provision for a ninety days' notice of such intention.

The operating division of the combined companies will be located at 8 and 10 Bridge street, New York, and the executive offices of American Ship & Commerce will be in the new Kerr Line building.

The vessels to be operated by the United American Lines are:

Kerr Navigation Company fleet—*Keresan, Kerlew, Kerowlee, Kerkenna, Keresaspa, Kermoor, Kermit, Kermanshah, Monticello, Montpelier.* Total, 10.

American-Hawaiian fleet—*Alaskan, American, Arizonian, Dakotan, Floridian, Hawaiian, Iowan, Kentuckian, Mexican, Minnesotian, Ohioan, Oregonian, Panaman, Pennsylvanian, Texan, Virginian, Missourian* (building), *Californian* (building). Total, 18.

Coastwise Transportation fleet—*Corsica, Franklin, Hampden, Middlesex, Norfolk, Suffolk, Plymouth, Transportation, Clarksburg, Steamer.* Total, 10.

Shawmut fleet—*Mystic, Ipswich, Sudbury*, two building. Total to be 5.

American Ship & Commerce Corporation—*DeKalb*, ex-German passenger steamer. Total, 1.

Livermore, Dearborn fleet—Shipping Board steamers. Total deadweight between 150,000 and 200,000.

All the vessels of the Kerr fleet are ex-Austrians, purchased three years ago by consent of the Shipping Board, except the *Montpelier* and *Monticello*, which are ex-German.

Rotterdam-Seattle Service

Representatives of the Holland-American Line announce plans for the inauguration of freight and passenger service between Seattle and Pacific Coast ports and Rotterdam, Antwerp, London, Liverpool, Hamburg and other European ports. Three 12,000-ton freighters have been named for the Pacific, loading in Seattle, to commence with the steamer *Eemdyke* in October. The freighters will be fitted with large cooling rooms and refrigerators for the transportation of fresh fruit, fish and other Puget Sound products. For the present cargo carriers only will be sent to the Pacific.

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PLANS BIG DEVELOPMENT

$35,000,000 for Tankers to be Expended by Atlantic, Gulf and West Indies

The Atlantic, Gulf & West Indies Steamship Lines, which is associated with the building of a pipe line to carry petroleum between Havre and Paris, is, it is reported, planning to expend between $50,000,000 and $60,000,000 in connection with the development of its oil properties. More than half of this amount, or about $35,000,000, will be used to purchase tankers for the transportation of its Mexican oil. A fleet of fourteen tankers is already under construction.

It is stated that no new financing is contemplated in connection with the big expenditure. The company is said to have available at the present time about $50,000,000 for the purposes contemplated. The company made large profits during the war and amassed a big surplus.

It is planned to expend about $10,000,000 on the development of its Mexican properties and from $8,000,000 to $10,000,000 will be expended in the construction of pipe lines. It is asserted that the major portion of the French undertaking, which calls for the construction of refineries, storage tanks and pipe lines, will be financed by Atlantic, Gulf and West Indies. About $2,000,000 will be spent on the development of properties in England, which have recently been acquired. In connection with the British project the Agwi Petroleum Corporation, Ltd., has been formed, with a capital of £1,000,000, and 65 percent of the stock is owned by Atlantic, Gulf & West Indies. Recently 466 acres of ground were purchased at Southampton, England, and on this property a topping plant will be erected.

The development work in Mexico is being carried on on an extensive scale.

JULY'S REGISTER RECORD

171 Vessels Numbered in Month by Navigation Bureau

One hundred and seventy-one sailing, steam, gas and unrigged vessels, aggregating 214,840 gross tons, built in the United States, were officially numbered in July, according to the Bureau of Navigation of the Department of Commerce.

Of these, 95, of 125,196 tons, were built on the Atlantic and Gulf coasts, 51, of 75,892, on the Pacific Coast, 21, of 13,671, on the Great Lakes, and 4, of 81 tons, on Western rivers. Twenty-four of the vessels of a total of 147,000 tons, were built for the Shipping Board.

Two vessels, the steel steamer *Julius Kessler*, 2,350 gross tons, and gas schooner *Fidelity*, of 40 gross tons, built in the United States for foreign account, were also numbered in July. The *Julius Kessler* is owned by the Julius Kessler Corporation, and flies the British flag.

From sources other than construction, two vessels of 11,552 gross tons were admitted to American registry under the act of September 7, 1916, two of 441 gross tons under the act of August 18, 1914, one of 8,797 gross tons under joint resolution of Congress, May 12, 1917, and one of 93 gross tons as a prize. Total six vessels of 20,883 gross tons.

DETAILS OF GERMAN SHIP DEAL

Combined Fleet to Be Run on 50-50 Basis—Passenger Ships to be Built

Details of the contract between the Harriman steamship interests and the Hamburg-American Line, recently made public, show that the agreement is on a partnership basis, in which the Germans share equally in all rights and privileges with the Americans. The resultant combined fleet is to be operated on a strictly 50-50 basis. Each side has the privilege of flying its own flag on 50 percent of the combined fleet. The Hamburg-American Company will fix rates on westbound traffic and the United American Lines, Inc., the operating company for the Harriman interests, will fix those on eastbound traffic. Lines will be operated to various ports of the world. There is to be an interchange of docking facilities. The contract is for twenty years. No statement is made as to what is contemplated beyond that period.

Under the contract, the American company has guaranteed to place 40,000 tons of steerage tonnage in operation between American and German ports before July, 1921. Plans are to be completed for the construction of four passenger liners of intermediate type, costing from eight to ten million dollars each, two to fly the German flag and two the American. The German ship *DeKalb*, now being reconditioned at the Morse works at South Brooklyn, will be used in the American company's passenger service, as well as two 13-knot ships now building by the Merchant Shipbuilding Corporation, which will be converted to third-class passenger carriers.

According to the contract "each service is considered a unit," and each side "may transfer for execution" any service covered by the contract to any other company of the same nationality. Disputes are to be settled by arbitration.

No German money is to be invested in the American company. The contracting parties are to have reciprocal advantages in developing trade, and each is to furnish agents in its own country for the other. Negotiations for the deal have been conducted by W. G. Sickel, formerly representing the Hamburg-American.

R. H. M. Robinson, president of the Merchant Shipbuilding Corporation, will soon leave for Germany to consult with the designers of the Hamburg-American Line regarding new tonnage for that line. It is stated that the Hamburg-American interests placed an order for 185,000 gross tons of ships before the contract was signed.

TO BUILD BIGGEST FIGHTER

Fore River Yard to Construct the Lexington, World's Greatest Battleship

The Fore River (Quincy, Mass.) yards of the Bethlehem Shipbuilding Corporation, Ltd., is to begin construction, within a few months, of the United States battleship *Lexington*, which will be larger and more heavily armed than any American, French, British or French boat built or building.

She will carry eight 16-inch guns in her main battery, with a plentiful supply of smaller guns. Her speed, estimated at 35 knots, will be obtained in part by the use of thin armor plate, which, while only 5 inches in thickness, will be of much greater strength than any now in use.

The *Lexington* will be 874 feet long over all, with 101 feet beam, and will displace 43,200 tons. She will be an oil burner, with electric drive, and will develop 180,000 horsepower. She will be larger and four knots faster than the British battleship Hood, now building.

Chicago Section American Welding Society Organized

At a meeting of members of the welding trade in Chicago, in the rooms of the Western Society of Engineers, on August 3, a Chicago section of the American Welding Society was organized. There were about seventy-five in attendance, representing many railroads terminating in Chicago, also many of the larger local industries. The following officers and directors were elected: Chairman, M. B. Osborn, assistant superintendent, Pullman Car Works; vice-chairman, O. T. Nelson, president, General Boilers Company; secretary-treasurer, L. B. Mackenzie, president, *The Welding Engineer*.

Directors—Three Years.—E. Wanamaker, electrical engineer, Rock Island Railway; H. B. Bently, superintendent motive power and machinery, C. & N. W. Ry.; Andrew Oliver, welding supervisor, Standard Oil Company; W. M. B. Brady, commercial engineer, General Electric Company. Two years—Harold Cook, managing editor, *Acetylene Journal;* W. A. Slack, president, Torchweld Equipment Company; K. R. Hare, district manager, Transportation Engineering Company; J. M. Jardin, partner, Western Welding & Equipment Company. One year—W. H. Bleecker, Jr., district manager, Page Steel & Wire Company; Oliver Mitchell, partner, A. F. Mitchell & Son; Walter L. Senhert, president, Welded Products Company; Don B. McCloud, secretary-treasurer, Gas Products Association.

Meetings will be held on the second Tuesday of each month in the rooms of the Western Society of Engineers, and those interested in the subject of autogenous welding, by all methods, are invited to attend. The address of the secretary-treasurer is 608 South Dearborn street, Chicago.

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57,314,000 GROSS TONS IN WORLD STEAM AND SAILING FLEETS

British Pre-War Lead Reduced To About 2,300,000 Tons—America Behind In Steel Tonnage, But Ahead In Wooden, Both Steam and Sail—Changes In Proportional Growth.

Despite the great growth of the American merchant marine and the intensive production of ships in the United States and the United Kingdom, the world's steel steam tonnage to-day is three and a half million gross tons less than it would now have been if the war had not interfered with the normal rate of expansion, says a statement just issued by Lloyd's Register of Shipping, and based on data contained in the 1920-21 edition of Lloyd's Register Book.

Although Britain is now building nearly 1,500,000 gross tons of ships more than this country, it is stated British holdings of steamers are still 781,000 tons below the total at the outbreak of war.

The world total for all types of vessels over 100 gross tons, however, is now 57,314,000 gross tons, an increase of 8,225,000 tons over the pre-war figure. Of this amount the United States holds 16,049,000 tons and the United Kingdom 18,330,000 tons, the British lead, which before the war was nearly 14,000,000 tons, having been reduced to about 2,300,000 tons.

In steel steamers, however, the British lead is a larger one, the margin in this case being 4,686,000 tons. American holdings of wooden steamers are much greater than the British, and this country also leads in sailing tonnage by a wide margin. The distribution of the tonnage of the two countries by types is as follows (in gross tons):

	United States	United Kingdom
Steel steamers.....	13,113,000	17,798,000
Iron steamers.....	227,000	277,000
Wooden steamers..	1,234,000	35,000
Total steamers..	14,574,000	18,110,000
Sailing ships.....	1,475,000	220,000
Total all ships...	16,049,000	18,330,000

Holdings of all types of vessels by the two countries and the other maritime nations at June 30 of 1914, 1919 and 1920, are given by Lloyd's Register as follows (figures in gross tons):

	1914	1919	1920
United States.....	5,368,000	13,092,000	16,049,000
United Kingdom	19,257,000	16,555,000	18,330,000
Other countries	24,464,000	21,272,000	22,935,000
World total	49,089,000	50,919,000	57,314,000

These figures indicate that while the United States has trebled its pre-war holdings, Great Britain and all the other maritime nations combined are still about two and a half million tons below their 1914 total. During the past year the American merchant marine grew by nearly three million tons, while the United Kingdom's gain was only about half that, with the other nations advancing about the same amount.

The reduction in the world's sailing tonnage since 1914 has been 641,000 tons, a much smaller decrease than in the previous six-year periods. This would seem to show that the general shortage of tonnage has to some extent given new life to the construction of sailing vessels. The United States is the only country which has increased its volume of sailing tonnage since the beginning of the war, and it now owns 43 percent of the world's total. The proportion of sailing vessels in the world's tonnage is now under 6 percent, as compared with 8 percent in 1914 and 22 percent in 1902.

According to the new Register there are now 5,082 sailing vessels of 3,409,000 tons and 26,513 steamers of 53,605,000 tons, making a world total of 31,595 vessels of 57,314,000 tons. Apart from Germany and Austria the United Kingdom and Greece are the only nations which show any considerable reduction in the steam tonnage now owned as compared with 1914. Denmark and Sweden show minor losses and Norway a small gain. Most of the other countries have increased in tonnage holdings, some to a very considerable extent.

The seagoing tonnage of the United States has increased nearly 10,400,000 tons, an advance of over 500 percent on the 1914 figures. The other countries in which the largest increases are recorded are: Japan, 1,288,000 tons; France, 1,041,000 tons, and Italy, 638,000 tons. As in the case of the United Kingdom, the figures for France and Italy include a considerable amount of ex-enemy tonnage provisionally allocated to those countries.

How the maritime position of Germany has changed is shown conclusively by the figures. While in 1914 Germany occupied, after the United Kingdom, first place, with over 5,000,000 tons of merchant steamers, only 419,000 tons are now recorded in the Register Book as German, everything else having been either captured, requisitioned, sunk or allocated to the Allies in accordance with the peace treaty.

The relative positions of some other countries has also altered to a large extent. In 1914 the United Kingdom owned 41.6 percent of the world's steam tonnage, while the present figure is 33.6 percent. Norway, which occupied the fourth place, is now seventh, while Japan, which was sixth, is now third.

Excluding vessels trading on the Great Lakes (about 2,300,000 tons), the United Kingdom percentage of the world's seagoing steam tonnage has decreased from 43.9 in 1914 to 35.1 in 1920; while the proportion of the United States, which was 4.7 percent six years ago, has now reached 24 percent.

The Register shows that nearly 27,750,000 tons of shipping are actually cleared or about to be classed by Lloyd's, and that the existing vessels which were formerly classed total about 8,850,000 tons. That the recognition of the value of classification is world-wide is shown by the fact that of the more than 25,000,000 tons of vessels actually appearing as classed in the new book, 14,000,000 tons are of vessels owned outside of Great Britain. Of the total steel and iron merchant tonnage now in existence about 62 percent has been built under the survey of Lloyd's Register. During the calendar year 1919 the new vessels classed by Lloyd's aggregated 4,283,000 tons, of which nearly 2,200,000 were built in the United States.

SEATTLE'S GREAT PIER

Opened for Service With 946,860 Square Feet of Floor Space

Seattle's new Pier B at the Smith Cove Terminal, the largest cargo pier in the world, opened August 5, when the Mitsui steamship *Horaisan Maru* was docked at one end of the great structure, which is 2,580 feet long and 367 feet wide, having an area of 946,860 square feet. Eleven ships the size of the *Horaisan Maru* can discharge cargo at this waterfront giant simultaneously. The *Horaisan Maru* brought a cargo of 8,344 tons. The terminal now consists of two piers, A and B, and together they form a whole port in themselves, capable of handling millions of tons of cargo each year. There are 68 other cargo piers along the waterfront.

The estimated cost of new transit shed and passenger accommodations on Pier B is $232,644. The Pacific Steamship Company will dock its Oriental passenger liners which will be sent to the Pacific Coast by the Shipping Board at this terminal, starting in September, at Pier B.

Tanker Construction August 1

According to a statement by the Atlantic Coast Shipbuilders' Association, as of August 1, at present 119 tankers of 812,325 total gross tonnage are ordered from or building in American shipyards. This is an increase in tanker orders on hand of 9,000 tons compared with May, and 67,185 compared with April.

3,554,352 Tons Built in Year

During the twelve months ended July 31, this year, American shipyards turned out 2,086 vessels of 3,554,352 gross tons. Of these, 674 were steel ocean steamers, aggregating 3,146,257 gross tons. Twenty-four vessels of 147,089 gross tons were built for the United States Shipping Board.

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PERSONAL NOTES

P. I. Rhodes has been appointed New York representative of the Union Shipbuilding Company, of Baltimore, with offices at 50 Church street.

Louis F. Swift, of the Chicago packing firm of Swift & Company, has resigned from the directorate of the Green Star Steamship Company, 115 Broadway.

Colonel Guy Goff, general counsel for the Emergency Fleet Corporation, will also be general counsel for the Shipping Board, placing the legal departments of both organizations under one head.

Brigadier-General Frank T. Hines, whose recent resignation from the army came as a surprise, has entered the steamship business as general manager of the Baltic Steamship Company, 17 Battery Place, New York.

Lester C. Neff has resigned his position as Galveston agent of the Shipping Board, and will come to New York as assistant general manager of the Export Steamship Company, Inc., better known as the Oriole Steamship Company of Baltimore.

A. J. Frey, director of construction and repair of the Emergency Fleet Corporation, has resigned, and will become manager of the Los Angeles Steamship Company. He was formerly connected with the old Pacific Mail Steamship Company.

Frederick A. Jones, formerly vice-president and general manager of the Eastern Steamship Corporation, with headquarters at Boston, and during the war in the employ of the United States Shipping Board, has been appointed manager of the Hobbs Manufacturing Company at Worcester, Mass.

Calvin Tompkins, former president of the American Association of American Port Authorities, and former Dock Commissioner of New York City, has been on an inspection tour of Pacific Coast ports, and was the guest while at San Francisco of J. B. McCallum, president of the California State Board of Harbor Commissioners.

The National Safety Council announces the appointment of R. T. Read, of the safety department of E. I. du Pont de Nemours & Company, as permanent secretary of the Delaware local council; also of J. C. Townsend, formerly safety engineer for the International Shoe Company, of St. Louis, as manager of the Grand Rapids division of the National Safety Council.

Mr. Charles M. Manly, who during the war was busy with the production of aircraft, has finished his term of office as president of the Society of Automotive Engineers, and in connection with Mr. C. B. Veal, under the firm name of Manly & Veal, consulting engineers, has opened offices at 250 West Fifty-fourth street, New York, for the investigation of industrial propositions, the rehabilitation of manufacturing concerns, and the installation of inspection systems that operate to increase production and decrease costs of manufacture.

TRADE PUBLICATIONS

Rock Drills.—Bulletin 504, recently issued by the Chicago Pneumatic Tool Company, 6 East Forty-fourth street, New York, describing the Slogger rock drill, is now available, upon request, from the New York office or any branch office.

Adjustable Speed Motors.—This bulletin describes recent developments in the design of R F, Form A, direct-current adjustable speed motors, produced by the General Electric Company, Schenectady, N. Y. Complete specifications are also given to aid in the replacement of worn parts of these motors.

Windlasses.—A pamphlet describing spur geared ships' windlasses has been issued by the S. Flory Manufacturing Company, Bangor, Pa. In the construction of this new windlass steel instead of cast iron is used wherever possible, so that the machine is capable of withstanding the heaviest service. Steel spur gears are used for the drive instead of worm gears usually found in windlasses.

Marine Glue.—In a pamphlet issued by L. W. Ferdinand & Company, 152 Kneeland street, Boston, Mass., the uses of Geoffrey's marine glue are described. Among other applications of this glue may be mentioned backing for armor plates, covering for deck and hull seams, making hollow spars for covering small boats and decks with canvas. In each case directions are given for applying the glue where it is to be used in connection with linen or canvas.

The Compass.—The latest issue of the Vacuum Oil Company's bulletin contains an account of the construction contest between two new tankers which were being built at the Sparrow's Point yard of the Bethlehem Shipbuilding Corporation and at the Moore yard of the Bethlehem Shipbuilding Corporation. This issue also includes the requirements for motorboat engine lubrication, as well as an excellent collection of photographs of the company's tanker float.

Fan Systems.—The most recent publication of the Buffalo Forge Company, Buffalo, N. Y., Catalogue No. 700, contains valuable engineering data on the design and installation of heating, ventilating and humidifying systems for all purposes. In fact, complete calculations for the apparatus to be used in connection with any of these services are carried out, special examples being used to illustrate their application. Charts and tables dealing with the three subjects have been compiled so that the catalogue is in effect a handbook of ventilating and heating.

Deflection Potentiometer.—The second edition of the General Electric Company Bulletin No. 46112, describing the deflection potentiometer has just been issued. This instrument is designed particularly for giving accuracy between the precision potentiometer and the laboratory standard. There are certain changes in the design and the arrangement of the circuits mentioned, which permit measuring potential up to 1.5 volts to within 0.0002 volt without a volt multiplier. Current may also be measured by means or shunts giving direct ampere readings.

Refrigerating Plants.—The Norwalk Iron Works Company, South Norwalk, Conn., gives a complete description of its new product, the "Norwalk" refrigerating plant, in Bulletin No. 6, which has recently been issued. Various types and capacities of this machine, both for land and marine installations, are completely illustrated. The special features of the plant are its compact and sanitary arrangements, and the fact that it requires but little attention for satisfactory operation. The company will be interested in supplying complete information and submitting quotations for refrigerating or ice-making plants of any size or covering any special requirements.

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ITALY

COLLEGIO DEGLI INGEGNERI NAVALI E MECCANICI IN ITALIA,
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Marine Construction News of the Month

Ship Contracts—New Ship Concerns and Shipyard Improvements—Terminal Projects—Government Contracts

SHIPS AND SHIPBUILDING

Tanker, Chester, Pa.—One of 12,000 deadweight tons for the Sun Company, of Philadelphia, is to be built by the Sun Shipbuilding Company.

Boat Building Plant, Seattle, Wash.—The Tregoning Boat Company is constructing a new plant for building small boats. Frank Tregoning is president.

Tankers, Portland, Ore.—The Standard Oil Company of New Jersey has contracted with the G. M. Standifer Construction Company, of Portland, Ore., for two tankers of 8,000 tons each.

Converting Steamer, Seattle, Wash.—J. F. Duthie & Company have undertaken to convert the Japanese-built American steamer, Eastern Exporter, into an oil burner for $101,396.

Passenger Steamer, San Francisco, Cal.—A contract for building a 16,340-ton passenger and cargo steamer for the Southern Pacific & Atlantic Steamship Company has been let to the Moore Shipbuilding Company.

Tanker, Chester, Pa.—A contract was placed by the Tidewater Oil Company with the Sun Shipbuilding Company for the construction of a 10,000-ton tank steamer on which work will probably begin within the next few weeks.

Tankers, Portland, Ore.—The Northwest Bridge & Iron Works has contracts for seven oil tankers for Canadian interests. The ships will be 12,000-ton capacity and the plant will employ 5,000 men. The second keel was laid a few weeks ago.

Steam Schooner, Portland, Ore.—The keel for a steam schooner for the Hart-Wood Lumber Company was laid at the Peninsula Shipbuilding Company's yard. The ship will have a capacity of 1,200,000 feet of lumber, and will cost about $100,000.

Reconditioning Steamer, New York.—New bids are being asked by Ferdinand Eggena, 17 Battery Place, New York, for the reconditioning of the ex-German steamer Von Steuben, which he recently purchased. The estimated cost is $3,000,000.

Shipbuilding Machinery, Bath, Me.—It is reported that the Hooven, Owens, Rentschler Company, of Hamilton, Ohio, and 39 Cortlandt street, New York, has sold to the Bath Iron Works a large order of marine construction and shop machinery.

Cargo Steamers, Baltimore, Md.—The Union Shipbuilding Company is about to lay the keels for two 9,500-ton cargo steamers that it is building for yard account. Keels for two 9,700-ton tankers for the Gulf Refining Company were recently laid.

Coal Barge, Linton, Ore.—Plans have been completed by Supple & Martin to convert a half-finished wooden Shipping Board hull into a coal barge for use in the local harbor. The barge will be equipped with powerful cranes and tracks, on which coal cars can be run.

Tankers, Camden, N. J.—W. R. Grace & Company have contracted with the New York Shipbuilding Corporation for building a 10,000 deadweight ton tanker. One of the 9,800 deadweight ton tankers of the Pacific Mail Steamship Company is also to be built by the company.

New Shipbuilding Company, Milford, Conn.—The Milford Shipbuilding Company, recently organized, has acquired about 22 acres on the Housatonic River for the erection of a plant. Initial equipment will be for the production of light draft boats, power operated, for coastwise service.

To Use Wooden Hulls.—Several of the Shipping Board's idle wooden hulls on the Pacific Coast are to be converted into barkentines for overseas business by a Seattle concern called the Pacific Packet Line. The Winneton Shipping Company, a new concern, is connected with the packet company.

Shipbuilding Company Liquidates, Three Rivers, Que.—The Three Rivers Shipyards Company, Ltd., a subsidiary of the National Shipbuilding Company, New Orleans, La., has gone into liquidation, and a meeting will be held in the near future to appoint a liquidator who will wind up the affairs of the company.

Company Reorganized, Northport, L. I.—The Northport Shipbuilding Corporation has filed notice of dissolution, to be superseded by the Northport Shipyards, Inc., organized with a capital of $100,000. H. E. Bogdish, M. D. Flomenhaft and G. N. Dorney, 244 West 134th street, New York, are the incorporators.

Whalers, Oakland, Cal.—Two electrically-driven whalers, each 100 feet long, and said to be the most efficient craft of their kind ever devised, are under construction at the Barnes & Tibbitts yards for a new whaling concern, which will build a plant and operate from Drakes Bay, just north of the Golden Gate.

Completing Steamer.—The Shipping Board expects to complete the first of the new 12,600-ton passenger liners being built in Pacific Coast yards for traffic with the Orient by September 15. It will be named the Wenatchee, and will be operated by the Admiral Line, a subsidiary of the Pacific Mail Steamship Company.

Steamers, San Pedro, Cal.—Two new steamers, to cost $4,000,000 each, will be built for the Admiral Line. The Southwestern Shipbuilding Company and the Los Angeles Shipbuilding Company, both of San Pedro, have been requested to bid on the work of construction. The vessels will be 560 feet in length and have a gross tonnage of 21,000.

Barges, Mobile, Ala.—The Murnan Shipbuilding Company's contract with the Marion Oil Company, of Tampico, Mexico, calls for the completion of ten 7,500-barrel oil barges and a tugboat by November. Two of the contracts for twelve barges have just been completed. It is also building barges for J. O. Williams, of Havana, for use in the sugar trade.

Subchasers as Fishing Boats.—North Pacific fishermen are reported to have purchased some of the Government's submarine chasers which have been offered for sale and converted them into fishing boats, which have proved very successful. It is expected that a large number of the chasers now laid up will be used for that purpose in the near future.

Ocean-going Tugboats, Pensacola, Fla.—The Pensacola Shipbuilding Company will undertake the construction of a number of large ocean-going tugboats, according to an announcement made at the plant directly after the last of the large steamships went into the water. The work of fabricating the steel for the first of the 1,400-ton tugs was started August 2.

Reconditioning the DeKalb, Brooklyn, N. Y.—The Morse Dry Dock & Repair Company has the contract for reconditioning the DeKalb, ex-Prinz Eitel Friedrich. The contract calls for 120 working days and will require the services of hundreds of ship repairers. The DeKalb is of 8,797 gross tons, 55 feet 7 inches beam, 32.1 depth, and 506 feet long.

Repair Steamers, Baltimore, Md.—The Baltimore Dry Docks & Shipbuilding Company has been awarded a contract to repair the steamship Nantucket, of the Merchants & Miners Transportation Company, to cost about $150,000. The steamship Kershaw of this line will also undergo repairs to cost about the same price. Four new Scotch boilers are to be installed.

Subchaser for Fireboat, Seattle, Wash.—Purchase from the Federal Government of one or more subchasers for conversion into fireboats was suggested to the City Council of Seattle by Frank L. Stetson, chief of the Seattle Fire Department. Two of the boats available are at the Puget Sound Navy Yard. They originally cost $80,000, but will be sold for $12,000.

Schooners, Boothbay, Me.—Some time in October the four-mast schooner Zebedee E. Cliff is to be launched at the yard of the East Coast Ship Company. At the Atlantic Coast yard, owned by Crowell & Thurlow, of Boston, the Joshua B. Merrill, a sister ship of the four-master J. W. Howard, will be launched in December, and the keel for another has been stretched.

Ships to Be Sold in Seattle, Wash.—Negotiations are in progress for the sale of the motorship Muriel, recently launched from the Anderson's Lake Washington Shipyard, and the Donna Lane, a sister ship. The lumber carrying capacity of each vessel is 1,736,596 feet, the underdeck capacity being 1,293,792 and the deck load capacity 442,804 feet. Each ship has three hatches.

Barge, Winslow, Wash.—The first of the Shipping Board's Ferris type ships to be converted into an ocean-going barge was launched from the Winslow Marine Railway & Shipbuilding Company's yard at Eagle Harbor, for the Coastwise Steamship & Barge Company. When in commission this barge will be equipped with the most modern towing devices as well as cargo-handling apparatus.

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Trawlers, East Boothbay, Me.—Two steel trawlers are on the ways at the Rice Bros. yard, and two others are under way outside. Work on them has been suspended for some time, but it is expected they will be started up again soon. The vessels are 152 feet long, 24 feet beam and 15 feet deep. The Rice Bros. have developod their former small boat plant into a well-equipped steel shipbuilding concern.

Steamer, Bath, Me.—The Bath Iron Works has secured a contract from Crowell & Thurlow, of Boston, to build another 9,500 deadweight tons steamer to be a duplicate of the one now on the ways. She will be 410 feet long, 55 feet beam and 34.5 feet deep, with triple expansion engines, and a speed of 10 knots. There will be three Scotch boilers, and the furnaces will be designed to burn eithr coal or oil.

Tankers, Sparrow's Point, Md.—The Bethlehem Shipbuilding Corporation's plant will lay the keel for the first of two oil tankers for the Lux Navigation Company of London, England, in September. The vessels will have an overall length of 427 feet,, with a beam of 53 feet and a hold 31 feet deep, with a deadweight tonnage of 8,400 tons. Steam will be supplied to a triple expansion engine by three Scotch boilers; speed, 11 knots.

Ferryboat, New York.—The Board of Estimate has appropriated $600,000 for the construction of a new ferryboat for the Staten Island line, and appropriated $45,000 for the purchase of the ferryboats Steinway and Bowery from the New York East River Ferry Company. Commissioner Whalen, of the Department of Plant and Structures, received $110,000 for the reconstruction of the boats and $16,210 for operating expenses for September.

Freight Steamer, Newburgh, N. Y.—With the recent launching of the 9,000-ton deadweight steel freight steamer, Storm King, the Newburgh Shipyards, Inc., completed its contract with the Shipping Board. The vessel is of the two-deck, poop, bridge and forecastle type, having a bronze propeller driven by a triple expansion engine of 2,000 horsepower, with three Scotch boilers. The vessel is arranged so as to be quickly converted for burning oil if desired.

Ferryboat, Groton, Conn.—Word from Boston is to the effect that the Groton Iron Works, Groton, Conn., a subsidiary of the United States Steamship Company, 50 Church street, New York, has won the contract for building a large steel ferryboat for the city of Boston. Officers of the company say they are daily in receipt of inquiries regarding the building of freighters and tankers. The second is to be built by the Winnisimmet Shipyards, Chelsea, Mass.

Stoel for Ship.—Twelve hundred tons of steel to rebuild the steamship Liberty Glo, the vessel built at Hog Island and blown in two by a German mine in the North Sea eight months ago, have been sent to Rotterdam. The Liberty Glo struck the mine on last December 5, more than a year after the armistice was signed. The vessel parted amidships and the ends floated ashore. They were towed to Rotterdam on April 4, this year, and placed in a dry dock there.

Shipbuilding Company Organized, Manitowoc, Wis.—The Manitowoc Shipbuilding Corporation has been organized under the laws of Wisconsin, with an authorized capital of $1,500,000, by A. L. Nash, Lawrence W. Dedvin and E. L. Nash, to do general shipbuilding, dry dock and dockage business. The new corporation is formed by the interests which have acquired the bulk of the property of the Manitowoc Shipbuilding Company, one of the American Shipbuilding Company group which has completed its Government contracts.

Concrete Steamers and Tankers, Jacksonville, Fla.—The Newport Shipbuilding Corporation, Woodward building, Washington, D. C., has applied for a lease of 700 feet of the Bentley shipyard at Jacksonville, and the City Commissioners have set a price of $1,200 a year for the property. The concern is said to have Government contracts for eleven concrete river steamers and three concrete tankers, to cost approximately $5,000,000, and keep 500 or 600 men busy for at least two years. R. H. Arnold is general manager for the company.

Tanker Contracts Delayed.—Delays in the delivery of Scotch marine boilers have prevented the closing of additional contracts for the construction of ships in Pacific Coast yards. The Anglo-Saxon Petroleum Company is said to have vainly tried to place orders for tankers in many yards of the country. The Southwestern Shipbuilding Company and the Union Construction Company declare a report that they have closed contracts for Anglo-Saxon and Vacuum Oil tankers is premature.

To Recondition Steamer, New York.—The steamer Nopatin, purchased by the Hudson River Day Line, is to be reconditioned and her upper works rebuilt along the lines of the Washington Irving of the same line. J. W. Millard & Bro., 17 State street, New York, have plans for the work, and bids have been submitted by the Harlan plant of the Bethlehem Shipbuilding Corporation, Pusey & Jones, and the Bath Iron Works, but it is understood that the award has not yet been made. The steamer is to be renamed the DeWitt Clinton.

Tankers, New York.—Extensive plans for development, calling for expenditures aggregating between $55,000,000 and $60,000,000, have been worked out by the Atlantic, Gulf & West Indies Steamship Company, 11 Broadway. The development contemplated is to spread all over the globe, and includes building tankers in this country, improvement and extension of the company's properties in Mexico, construction of the first French pipe line, between Havre and Paris, and work on properties in England recently acquired by the company. Of the total amount about $35,000,000 will be for new tankers.

Barges, Newburgh, N. Y.—The Tank Steamship Corporation is building oil barges of 11,500 barrels capacity for the Southern Oil & Transport Company. These barges will be built on the transverse system of framing, square ended, raked bow and stem, flat-bottom, square bilges, straight sides, no shear, deck sloped, deck houses aft, with accommodations for two men. There will be three transverse oil-tight bulkheads and two longitudinal non-oil tight bulkheads, heating coils in each tank, loading through hatches, unloading through a large pump, with 12-inch suction and 10-inch discharge, capacity 2,000 barrels per hour.

Tankers, Camden, N. J.—The New York Shipbuilding Corporation has sold the two 9,820 deadweight tons tank steamers which were to be constructed for builder's account to the United Fruit Company and the Pacific Mail Steamship Company. The first will be delivered on February 1, 1921, to the United Fruit Company, and the second about May 1 to the Pacific Mail Steamship Company. Keels for two additional tankers for builder's account and to be sold later will be laid this fall. The company is also building nine of the 18-knot type and seven of the 14½-knot speed for the Government. It is announced that the American Line will also place a contract with the company for a number of liners having a registry of about 20,000 tons.

SHIPYARDS AND DRY DOCKS

Repair Plant Equipment, Mobile, Ala.—P. N. Auger, architect of the Kelly Dry Dock & Shipbuilding Company, has plans and specifications for improving the plant and for shop equipment, which call for the expenditure of about $150,000.

Dry Dock, Chester, Pa.—The Sun Shipbuilding Company is building a floating dry dock of 10,000 tons capacity, with wooden pontoons and continuous steel wings, from designs by William T. Donnelly, 17 Battery Place, New York. The dock will be 523 feet 6 inches long on the keel blocks, with an overall width of 110 feet.

New Dry Docks, Brooklyn, N. Y.—The Ramberg Dry Dock & Repair Company, Inc., plan improvements, including two new steel floating dry docks to lift cargo vessels of 10,000 and 14,000 tons. The power plant, foundry, machine shops, boiler shops, pattern and carpenter shops and store rooms will be enlarged, and improved machinery added to the plant.

Temporary Shut-Down, Pascagoula, Miss.—The International Shipbuilding Company, which has been running on Italian contracts, has been forced to shut down owing to the Italian exchange situation. It is expected to resume as soon as the money market is straightened out. Three steel ships are in the wet basin awaiting completion, one being due in October.

May Buy Pusey & Jones Yard, Gloucester, N. J.—The Bethlehem Shipbuilding Corporation is negotiating for the purchase of the Pusey & Jones plant. No papers have been signed, but an agreement has been reached as to the sale in case the present owners are able to reach a financial settlement with the Emergency Fleet Corporation and thus obtain a clear title to the plant.

Dry Dock.—The 8,000-ton floating dry dock which is being designed by Mr. William T. Donnelly for the Federal Ship Building Plant of the United States Steel Corporation, will have nine wooden pontoons, continuous steel wings extending the entire length, length over keel blocks 438 feet, length over the wings 377 feet, and a clear width between wings of 84 feet, and will take a draft of 22 feet over 4-foot keel blocks. There will be two centrifugal pumps in each pontoon, electrically operated. From a 440-volt, 3-phase, 60-cycle alternating current.

Shipyard Expansion, Milwaukee, Wis.—The Milwaukee Dry Dock Company, a member of the American Shipbuilding Company group, has an improvement programme involving an investment of $1,250,000. A new dry dock capable of accommodating Great Lakes vessels up to 625 feet will be constructed early in the fall or next spring. Work has started on a new pump house costing $75,000 with equipment and a new office building. Later additional machine shops and auxiliary buildings will be erected. F. W. Smith is secretary-treasurer and general manager.

Shipyard Improvement, Quincy, Mass.—The old cranes and runways serving submarine slips Nos. 1, 2, 3 and 4, Bethlehem Shipbuilding Corporation, Fore River, are being moved to make room for the erection of eleven new towers with the necessary runways and the placing of two new 120-foot span cranes. These cranes will have the same height as those on adjoining slips—110½ feet above mean low water. They are to be used in connection with the company's new slip No. 4, which has a concrete keelway 512 feet long, designed for vessels of a maximum length of 520 feet and 75 feet beam, and have a clear width between towers of 108 feet.

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SHIPPING DEVELOPMENTS

Steamship Line, Hayti.—The Republic of Hayti is to have a steamship line with native capital, principally for the export of sugar.

New Shipping Company, Newport News, Va.—The Atlantic Ship Service Corporation has been chartered at $25,000. H. H. Lackey is secretary and treasurer.

Steamer Sale Canceled.—Sale of five steamers to the Green Star Steamship Company has been canceled, and the ships have been assigned to the company under a managing agency agreement.

New Line to Antwerp.—The Lloyd Royal Belge Steamship Company established a passenger service between New Orleans, La., and Antwerp recently with the sailing of the 8,400-ton steamer Olympier.

Shipping Merger, English Lines.—It is reported from London, England, that the Union Steamship Company of New Zealand, the British India, and the Peninsula & Oriental Lines have merged.

Mobile Service Continued.—The Mallory Line service between New York and Mobile is not to be discontinued, as the company has arranged for the use of the Baltimore & Ohio Railroad Company's piers until October 1.

Extending French Service.—The Barber Steamship Company is planning extensions of importance in its French-Atlantic freight services. The concern has been active in the French steamship business for more than forty years.

Bremen-New Orleans Service.—The J. H. W. Steele Steamship Company plans to develop the former North German Lloyd trade routes between Bremen and New Orleans and other Gulf ports, as well as to Cuba and and Mexico.

Steam Schooner Line.—With the General Steamship Corporation as Puget Sound agent, the new steam schooner line to be known as the Coastwise Steamship Company will soon inaugurate service between North Pacific points and San Francisco.

Steamer Sold, Baltimore, Md.—The States Steamship Company has bought the Shipping Board wooden steamer Clio, 3,500 deadweight tons, for $175,000. The Clio was built by the Pacific American Fisheries Company, at Bellingham, Wash., in 1919.

Service to Australia.—Regular American steamship service between New York and Australia is expected to follow the sailing on September 10 of the British ship Fuitala, owned by the British India Line, but under charter to the American Steamship Line.

New Steamship Line, Baltimore, Md.—The Lone Star Oil Transport Company, Calvert building, Baltimore, Md., has been incorporated by James L. Watson, Ferdinand H. Butchorn and Thos. E. Hale, with a capital of $500,000, to operate steamships, barges, etc.

Begins German Service, New York.—The United States Mail Steamship Company's service between New York, Bremen and Danzig was begun on August 4 with the sailing of the steamer Susquehanna, Capt. George Dundas, with a full second cabin list and 500 third class passengers.

North Pacific Norway Service.—A direct steamship service between Puget Sound and the ports of Norway has been planned for the immediate future. While the products of the Northwest have been shipped to Norwegian ports for some time, they have been sent via the Atlantic seaboard.

Line to Far East.—The J. H. W. Steele Company plans a monthly service between New Orleans and the Far East, to begin with the steamer Canada Maru. The company is agent for the Osaka Shosen Kaisha. It is said that the fare to Yokohama will be $294 for cabin and $120 for steerage passage.

Package Service, New York.—The New York & Western Canal Line, Inc., has established a package service from Pier 6, East River, to Syracuse and Rochester. The boat Fred W. Barth has started the service from Rochester and the Willis B. Knapp from Syracuse. Maltus & Ware are the general managers.

New Shipping Company, Memphis, Tenn.—A shipping company, capitalized at $1,000,000, is being formed to fight the proposed order of the Interstate Commerce Commission placing Memphis freight rates on the "dry land" basis, and a fund of $75,000 is to be used to secure options on boats for use on the Mississippi River. It is proposed to operate boats between Memphis, New Orleans and St. Louis.

Holland's Shipping Service.—The Associated Dutch Shipping Company established a new line to Australia, to be known as the Holland-Australia Line. The Holland-America Line will open a joint service with the Royal Mail Steam Packet Company to North Pacific ports, and the Royal Dutch Steamboat Company is inaugurating regular sailings to Braila and Galatz. The Royal Dutch Lloyd has joined the Holland-South Africa Line.

To Raise Coastwise Rates.—Coastwise steamship lines expect to put new tariffs into operation by September 1, in accordance with the permission granted by the Interstate Commerce Commission to raise their rates as much as the railroads. Generally, it is understood, the rates will not be increased more than 25 percent, but some executives of coastwise lines are not sure about that advance being enough to allow them to operate at a profit.

Steamers Sold, Charleston, S. C.—The steamship Lehigh, which has been managed and operated by the Carolina Company for several months, was sold by the Shipping Board. The Cape Henry, another Shipping Board steamship, has been bought outright by the Atlantic, Gulf & Pacific Company. Both vessels are now at Charleston, S. C., awaiting delivery to their new owners. The steamer Marica, of 12,000 deadweight tons, has also been sold by the Shipping Board to the Luckenbach Steamship Company, New York.

Freight Service, Richmond, Va.—Harriss, Magill & Company, 35 South William street, New York, announce the formation of the Richmond-New York Steamship Company, of which they are managers. Two vessels, the Lake Frances and Lake Sterling, have been purchased from the Shipping Board, and will be used for a regular freight service between New York and Richmond and City Point, Va., the latter to serve Hopewell and Petersburg. Other vessels will soon be added. The company has purchased the terminal formerly occupied by the Old Dominion Line at Richmond, and has New York offices at 24 South William street.

Freighters Sold.—Two of the Skinner & Eddy freighters, the Robin Adair and the Robin Hood, have been sold by D. E. Skinner, president of the building company and head of the Robin Line, for $3,000,000, or a fraction of over $144 per deadweight ton, to the United States Steel Corporation. The ships were built at Seattle and are only a few months old. They are oil burners, equipped with geared turbine engines and can make a speed of 11 knots. They may be converted into coal burners in three hours' time, and are considered the best type of cargo carriers. The freighters at $144 per deadweight ton is considered significant, in that ships of American registry, constructed by a recognized builder, are below $150 per deadweight ton.

PORT IMPROVEMENTS

Wharves, Helena, Ark.—The municipality will construct wharves on the Mississippi River front. Address the Mayor.

Dock, Yonkers, N. Y.—Contract for a city dock at the foot of Main street has been let to G. W. Rogers, 29 Broadway, New York City; cost, $150,000.

Wharf, Norfolk, Va.—Hastings Wharf & Terminal Corporation chartered; capital, $100,000. G. T. Hastings is president and W. B. Hastings is secretary.

Municipal Dock, Pensacola, Fla.—The City Commission is having plans prepared for a municipal dock and a belt-line railway; a $400,000 bond issue has been voted for the purpose.

Dock and Sheds, Milwaukee, Wis.—The Rockwell Manufacturing Company, 582 Park street, has drawn plans for the construction of a concrete dock and lumber sheds at Sixth street, Milwaukee.

Docks, Piers, Etc., Baltimore, Md.—The city votes on November 2 on a $10,000,000 bond proposition to provide for docks, piers, warehouses, etc.; H. G. Peering, City Hall, in charge as engineer.

Crane, Humboldt, Cal.—Specifications are being worked out for a 20-ton narrow gauge locomotive crane for use in shore protection work at Humboldt, Cal., by George F. Whittemore, engineer in charge.

Piers, Toledo, Ohio.—The municipality will purchase the wharves of one of the lake navigation companies as the first step in a programme calling for development of an extensive municipal pier system.

Bulkhead and Dock, Bridgeport, Conn.—Contract for a 250-foot bulkhead and 200-foot dock on wood pile foundation has been let to J. Pardy Construction Company, 1481 Seaview avenue; about $60,000.

Pier, Seattle, Wash.—The Great Northern Railroad, 712 Second street, let contract for rebuilding Smith Cove pier, 600 feet long and 122 feet wide, to J. A. McEachern Company, Colman building; about $75,000.

Bulkhead, Piers, Etc., Chester, Pa.—The Sun Shipbuilding Company has let a contract for bulkhead, piers and dredging to J. E. Brenneman, North American building, Philadelphia, to cost about $500,000.

Wharf, Seattle, Wash.—The Grant Smith Construction Company will build a wharf 1,000 feet long and warehouse at the plant of the Fisher Flouring Mill Company, on Harbor Island, Seattle; cost, about $250,000.

Docks, Tampa, Fla.—The Denton-Shore Lumber Company, Philip Shore, president, will improve export docks and secure additional 600 feet frontage, and probably will duplicate its 60,000 feet capacity resaw plant.

Pier, Everett, Mass.—Contract for a pier, approach and foundation, of reinforced concrete, for Merrimac Chemical Company, 148 State street, Boston, has been let to Aberthaw Construction Company, 27 School street, Boston.

Dredging.—Bids are to be asked for about 480,000 cubic yards of floating dredge work, and about 300,000 cubic yards of laterals in the Laban Bayou district, Mississippi. W. W. Boone, civil engineer, Cleveland, Miss., has details.

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Wharf, New Orleans, La.—Port Commissioners, 200 New Orleans Court building, will improve First Street Wharf; concrete floors, chain walls, paving, earth fill, etc.; 170,000 square feet, $200,000. Arsene Perrilliat, chief engineer.

Dock, Tacoma, Wash.—Surveys have been made by the Puget Sound Navigation Company for the erection of a dock and waiting room for the passenger steamers of the company here, made necessary by the increased rental demanded for the municipal dock.

Dredging.—Twelve miles of floating dredge work, involving 350,000 cubic yards of excavation, and 12 miles of laterals involving about 150,000 cubic yards of excavation, are to be undertaken in Bolivar County, Miss. W. W. Boone, civil engineer, Cleveland, Miss., has details.

Ocean Terminal.—Involving property valued at nearly $2,000,000, the First National Bank of San Francisco has acquired the controlling ownership in the East Waterway Dock & Warehouse Company and its ocean terminal on Harbor Island, Wash., and will make improvements.

Coal Terminal, Mobile, Ala.—A site for a coal terminal has been selected here, and will be recommended to Gen. W. D. Connor, head of the Inland Waterways Division of the War Department, together with designs, estimates, etc., and if approved a contract will be let for building the terminal.

Terminal, Tampa, Fla.—The Port Commission has been authorized to expend more than $500,000, and the engineers have plans ready for the first unit, to be built around a single slip running from the main ship channel about 825 feet back to a six-story warehouse, with loading platform, railroad tracks, etc.

Oil Storage Tanks.—Negotiations have been opened with the Shipping Board with a view to having some of the forty wooden hulls now lying in Lake Union, Seattle, Wash., converted into oil storage tanks at a cost not exceeding $40,000 each. In the Far East and other parts of the world there is an acute shortage of oil storage facilities.

Pier.—The Camden, N. J., Harbor Commission awarded a contract for the construction of a concrete pier on which will be built a $500,000 marine terminal at Spruce street to the Tilt-Hargan Company, 90 Broadway, New York, on a bid of $201,799. The pier will be 472 feet long and 102 feet wide. Construction is to start at once, and plans are being drawn for the terminal.

Terminal, Natchez, Miss.—H. McL. Harding, consulting engineer, is investigating conditions of Natchez harbor and making plans for river terminals. The Natchez Chamber of Commerce has communicated with the ship corporation formed at Memphis for the purpose of operating boats between Memphis and St. Louis and Memphis and New Orleans for information regarding the proposed lines.

Wharf, New Orleans, La.—Plans of the Dock Board include the building of a modern wharf on the west bank of the Mississippi for the Crescent Industrial Alcohol Company, to be equipped with pipe lines for loading vessels, and the installation of mechanical banana conveyors for the Cuyamel Fruit Company. Another item is the investment of $200,000 in making the First street wharf ratproof. The wharf is 1,800 feet long.

Terminal.—E. S. Walsh, superintendent of Public Works, Albany, N. Y., will receive bids until September 9, 1920, for building portions of dock wall around Ohio Basin, Buffalo, N. Y., contract 53-A; estimate, $426,000; also storage yards at Erie Basin, contract 76; also furnishing and installing jib cranes at Barge Canal terminal at Erie Basin, contract 114; also contract 26-A, for completing Barge Canal terminal at Rouse's Point, N. Y.; estimate, $26,000.

Bay Improvements, Newark, N. J.—Finance Commissioner J. F. Gannon, Jr., has been authorized by the Jersey City Commissioners to provide $650,000 for the improvement of Newark Bay and Hackensack River front from Droyer's Point to West Newark avenue, according to plans of Commissioner A. H. Moore and the Jersey City Board of Engineers. The plans call for extensive bulkhead work and the reclaiming of 85 acres of land.

Piers and Equipment, Philadelphia, Pa.—Hoisting, loading, conveying and other machinery for general freight service will be installed on piers and docks to be constructed by the Department of Wharves, Docks and Ferries. An ordinance has been approved by Mayor Moore authorizing the building of three double-deck piers, 160 by 530 feet, and 80 by 556 feet, respectively, with intervening docks about 170 feet long. The structures will be on the Delaware River, and are estimated to cost about $500,000, including equipment.

GOVERNMENT BUSINESS

Jetty, Jacksonville, Fla.—United States Engineer Office will receive bids until September 15, 1920, for building jetty at entrance to St. Johns River.

Dredging, Wilmington, Del.—United States Engineer Office rejected bids received July 15 for dredging waterway between Rehoboth and Delaware Bays.

Classified Advertisements will be found on Pages 162 and 163 of the Advertising Section

Dry Dock, Charleston, S. C.—Work is to begin soon on the navy dry dock here. Cost estimated $4,000,000. Commander G. S. Burrell, U. S. N., is in charge.

Dredging, New Orleans, La.—United States Engineer Office, Custom House, rejects only bid received July 30 for dredging Calcasieu Section Intracoastal Waterway, etc.

Barges, Nashville, Tenn.—United States Engineer Office will receive sealed proposals for four steel barges until 11 A. M., September 13, 1920. Further information on application.

Bulkhead and Wharves, Tampa, Fla.—United States Engineer Office, War Department, Washington, D. C., let contract for building bulkhead and wharves here to J. R. Chambliss, Tampa; $5,335.

Sale of Material.—The Shipping Board will receive bids until 11 A. M., September 16, for the machinery, equipment and materials at the yard of the National Shipbuilding & Dry Dock Company, Savannah, Ga.

Hog Island Yard to Be Sold.—The Shipping Board is offering the Government-owned shipyard at Hog Island for sale, and bids will be received by the Supply and Sales Division, United States Shipping Board, until 5 P. M., October 30.

Jetty, New Orleans, La.—United States Engineer Office, Custom House, will receive sealed proposals until 11 A. M., September 16, 1920, for extending jetties at the mouth of the Southwest Pass of the Mississippi River.

Repairing Wharf and Slips.—Specification 4260. The Bureau of Yards and Docks, Navy Department, Washington, D. C., will soon receive bids for repairing Wharf 3 and Slips 2 and 3; $10 deposit required for plans and specifications.

To Sell Concrete Tankers.—Two concrete tankers are offered for sale by the Shipping Board. They are of 7,500 deadweight tons each, with an estimated speed of 10½ knots. The vessels are being built at Oakland, Cal., are named the Palo Alto and Peralta.

Structural Steel Castings, Louisville, Ky.—United States Engineer Office will receive sealed proposals for furnishing and delivering structural steel castings, etc., for Lock No. 44, Ohio River, until 12 o'clock noon, central time, September 9, 1920. Information on application.

Harbor Development, Great Lakes, Ill.—Specification 4136, Bureau of Yards and Docks, Navy Department, Washington, D. C., will receive bids for developing harbor, to include dredging and filling, building breakwater, pier, quay walls, etc.; $10 deposit required for plans and specifications.

Barges, Gulfport, Miss.—The Gulfport Shipbuilding Company has received a contract from the United States Government for six barges to be constructed at the local yards, three of which will be 72 feet and the other three 61 feet in length. They will be fitted with high powered engines, and will be used for coastwise and inland waterways service.

Submarine Chasers to Be Sold, Washington, D. C.—The sale of 141 submarine chasers has been authorized by Secretary of the Navy Daniels. The suggestion is they may be converted into yachts, fishing boats, fireboats, police boats, and even small freighters. The Board of Survey, Appraisal and Sale, Navy Department, Washington, D. C., has charge of the sale.

Submarines.—Bids were opened August 18 by Secretary Daniels for the construction by contract of six of the nine fleet submarines which are authorized by the Naval Appropriation Bill of August 29, 1916. The other three are now under construction at the navy yard at Portsmouth, N. H. The lowest bid was by the Bethlehem Shipbuilding Corporation, with an offer of $3,900,000 each for the six, deliveries to start in thirty months. Other bidders were the Electric Boat Company and the Lake Torpedo Boat Company. The latter made a cost plus bid.

Tugs Bought.—Six of the bids made for twenty-five tugs have been accepted by the Shipping Board. The others were rejected because of unsatisfactory terms. The Cahill Towing Company, of New York, obtained the Artesan and Woodman at $83,000 each, having raised their original bids. The Pringle Barge Line Company, of Cleveland, obtained the Custodian for $83,000; the Standard Oil Company, of Indiana, the Outagamie for $200,000; Thomas J. Howard, of New York, the Toilers for $72,000, and the M. J. Dady Engineering & Contracting Company, of Brooklyn, the Craftsman for $83,000.

To Build Biggest Battleship.—Before the end of the year the United States Government will start construction on the world's largest, most powerful and fastest warship, the Lexington, at the Fore River plant of the Bethlehem Shipbuilding Corporation, Ltd., Quincy, Mass. Eight 16-inch guns will comprise the main battery, with numerous smaller guns. The boat will have a speed of 35 knots, obtained by use of armor plate only 5 inches in thickness, but of greater strength than any armor belt now in use. In the words of her designers the Lexington will be a "whale of a boat." Her length overall will be 784 feet, beam 101 feet, and she will displace 43,200 tons. Her power will be electricity, 180,000 horsepower in all. She will be larger and four knots faster than the British battleship Hood, now building.

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